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FOOD AND FEED

Acephate and Methamidophos Residue Behavior in Florida Citrus, 1976 [1]

Herbert N. Nigg,[2] James A. Reinert,[3] and George E. Fitzpatrick[3]

ABSTRACT

The half-life of acephate and its hydrolysate, methamidophos, in the rind of Temple and Valencia oranges, and grapefruit, lemons, and tangerines was 10.3 days and 10.5 days, respectively. Half-lives of acephate and methamidophos in citrus pulp were 15.0 days and 6.1 days, respectively, based on 7-, 14-, and 21-day data. Seven days after treatment, acephate and methamidophos reached maximum levels in rind and pulp. Acephate residue levels in rind were less than 3.0 ppm 14 days after treatment; acephate residues in pulp were less than 3.0 ppm throughout the experiment. Methamidophos residue levels averaged less than 0.25 ppm after 21 days.

Introduction

In 1937, the citrus blackfly, *Aleurocanthus woglumi* Ashby (Homoptera: Aleyrodidae), was eradicated from the Florida Keys by use of petroleum oil (*7*). Early in 1976, the citrus blackfly was again discovered in Fort Lauderdale, Florida, and surrounding Broward County (*8*). Infestations are currently found in Broward, Collier, Dade, Indian River, Martin, Okeechobee, Palm Beach, and Saint Lucie Counties (G. E. Fitzpatrick, University of Florida Institute of Food and Agricultural Sciences, October 1978: personal communication). After discovery of the infestations, an intensive state and federally sponsored eradication program was begun, but it was complicated by the urban nature of the citrus blackfly infestation.

Based on chemical efficacy and citrus blackfly life-cycle data, three treatments of acephate at 3-week intervals were necessary for eradication (*8*). Treatments were applied to all Florida citrus owned by individual homeowners in the heavily urbanized area under an emergency exemption granted by the United States Environmental Protection Agency (EPA). The homeowner was advised by the Florida and U.S. Departments of Agriculture to wait 7 days before consuming treated fruit.

It was not known whether acephate and its environmental metabolite, methamidophos (Monitor), would reach their respective action levels of 3.0 ppm and 0.25 ppm in whole fruit within 7 days. In addition, acephate and methamidophos are systemic chemicals and might readily penetrate fruit rind into the edible pulp.

The purpose of the present study was to monitor levels of acephate and methamidophos in common Florida citrus to determine half-lives and tolerances of these materials.

Materials and Methods

Each experimental unit consisted of one city block. Within each city block, a random 8-fruit sample was taken from 3–10 trees of Temple and Valencia oranges, and grapefruit, lemons, and tangerines on each sample date. Treatments were replicated four times in a completely random design including four unsprayed check blocks. Acephate at 0.6 g active ingredient(AI)/liter (ca 38 liters/tree) was applied with a hydraulic sprayer at 29 kg/cm^2 and with a mist blower at 2.4 g AI/liter (ca 0.8 liter/tree). The hydraulic sprayer was a standard, truck-mounted unit with two 100-m hoses and attached handheld sprayguns. The mist blower was a gasoline-driven backpack unit (KWH Whirlwind, Holland). Three separate treatments were applied at 3-week intervals. Dual samples of each variety were taken after the third application on days 1, 3, 5, and 7, and single samples of each variety were taken on days 14 and 21 by clipping the fruit into plastic bags. Each sample consisted of eight fruits. One set of the dual samples was washed in a weak soap solution of Ivory liquid to simulate homeowner washing. Samples were frozen at −20°C and transported frozen to the laboratory for analysis.

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Samples were stored approximately one month at −10°C prior to analysis. Valencia oranges were 0.8 mature when harvested; other varieties were completely mature.

The method of Leary (*4*) was modified for extraction and analyses of acephate and methamidophos. Fruits were thawed, the rind was removed from one half of each fruit, and the pulp was sliced into a Waring blender. The pulp was blended for 3 minutes, and a 10-g subsample was removed for analysis. The rind was diced, blended for 3 minutes, and a 10-g subsample was taken for analysis. Separate fruit knives were used for all operations, and between samples all equipment was washed thoroughly with hot soapy water, rinsed in tap water, deionized water, isopropanol, and again in deionized water.

The 10-g sample of either rind or pulp was homogenized in 100 ml ethyl acetate and 15 g sodium sulfate for 5 minutes in a Sorvall blending cup in an ice bath. The blender cup top was loosened upon removal from the mixer, and particulate matter was allowed to settle for 1 minute. A 20-ml aliquot was evaporated to dryness under a nitrogen atmosphere at 40°C, and transferred to brown glass bottles over sodium sulfate in 10 ml methyl isobutyl ketone (MIBK) for gas chromatographic (GC) analysis. No further cleanup was performed on the extractions, and they were stored at −20°C until analysis. The effect of storage on the hydrolysis of acephate to methamidophos was not determined.

For acephate and methamidophos, GC was conducted on a Hewlett-Packard Model 5730A gas chromatograph equipped with dual nitrogen-phosphorus detectors. Instrument parameters and operating conditions follow:

Column:	glass, 30 inches long × ⅛-inch ID, packed with 1 percent Reoplex 400 on 80–100-mesh Gas-Chrom Q
Temperatures, °C:	detector 300 injector 210 program 150–200 at 8°/minute, 8-minute final hold, 45-second delay after injection
Carrier gas:	helium flowing at 30 ml/minute

Compounds were quantified by comparing peak heights of standard materials chromatographed at the same attenuation. Unsprayed fruit extracts fortified with standard acephate and methamidophos (Chevron Chemical Co., Richmond, Virginia) were linear at each GC attenuation setting. However, at the attenuation setting of 8, standard materials chromatographed in MIBK alone produced a 10–20 percent lower response than in fortified fruit extracts. Fruit extracts alone were blank, apparently as a result of an unexpected synergistic effect of some component in the fruit extract on the nitrogen–phosphorus detector response. Consequently, fruit extracts fortified with acephate and methamidophos were used for quantification. Standards were chromatographed every fourth injection. All injections were 5 μl. All solvents were assessed for interferences by evaporating 100 ml of each solvent to 1 ml and chromatographing 5 μl.

Recoveries of standard materials from fortified homogenates were 73.1 percent methamidophos and 77.8 percent acephate at 1 ppm and 82.6 percent methamidophos and 85.4 percent acephate at 5 ppm for both peel and pulp. There were no varietal differences in recovery of standard materials. Variations in recovery averaged 16.8 percent for methamidophos and 15.3 percent for acephate at 1 ppm and 4.6 percent for methamidophos and 5.5 percent for acephate at 5 ppm. Lowest accurate level of detection for both standards was 0.01 ppm; lower levels are reported as trace. The data in Tables 1 and 2 are not corrected for recovery. No analyses were performed on either the formulated acephate or tank mixes. The equation for decay was:

$$y_t = y_o e^{-bt} \quad (1)$$

or

$$\ln(y_t/y_o) = -bt \quad (2)$$

Half-life, $t_{1/2}$, was calculated as

$$t_{1/2} = \ln(0.5)/(-b) \quad (3)$$

Residue levels were compared among varieties on individual sampling days and among sampling days for individual varieties with a t-test (*10*). Degrees of freedom were 14 for days 1–7 and 6 for days 14 and 21 [$df = 2(n-1)$] (*10*). Comparison of residue levels are significant at the 0.01 level.

Results and Discussion

There was no statistical difference between residues of acephate and methamidophos on or in washed and un-

TABLE 1. *Acephate residues in rind and pulp of Florida citrus, 1976*

	Day, Post Application					
	1	3	5	7	14	21
	Residues (Mean ± Std Dev.), ppm					
Temple orange						
Rind	2.3 ± 0.7	4.6 ± 1.6	2.8 ± 2.8	7.9 ± 5.8	2.6 ± 1.8	2.0 ± 1.2
Pulp	1.3 ± 0.5	0.8 ± tr	0.8 ± 0.5	2.6 ± 1.3	1.6 ± 0.8	1.2 ± 2.9
Grapefruit						
Rind	2.7 ± 2.1	1.9 ± 1.1	2.3 ± 2.1	3.9 ± 2.5	1.4 ± 0.2	1.9 ± 0.8
Pulp	0.3 ± 0.2	0.4 ± 0.3	0.4 ± 0.4	0.9 ± 0.6	0.5 ± tr	0.3 ± 0.3
Valencia orange						
Rind	3.9 ± 1.5	3.1 ± 2.5	4.1 ± 2.8	4.2 ± 1.5	1.8 ± 1.2	2.1 ± 1.3
Pulp	1.1 ± 0.7	0.6 ± 0.8	1.4 ± 0.5	0.7 ± 0.5	0.8 ± 0.3	1.0 ± 1.0
Lemon						
Rind	3.8 ± 2.2	5.7 ± 4.1	2.9 ± 1.8	6.2 ± 2.9	2.6 ± 1.8	1.4 ± 1.0
Pulp	1.5 ± 0.7	1.9 ± 1.0	1.0 ± 0.6	2.4 ± 1.6	1.3 ± 1.2	1.4 ± 0.9
Tangerine						
Rind	3.8 ± 2.3	4.9 ± 3.8	4.9 ± 2.1	4.9 ± 1.8	2.1 ± 1.2	4.9 ± 4.6
Pulp	0.7 ± 0.3	2.0 ± 1.3	1.3 ± 1.1	2.0 ± 0.7	0.9 ± 0.4	1.0 ± 0.6

NOTE: tr = trace = <0.01 ppm.

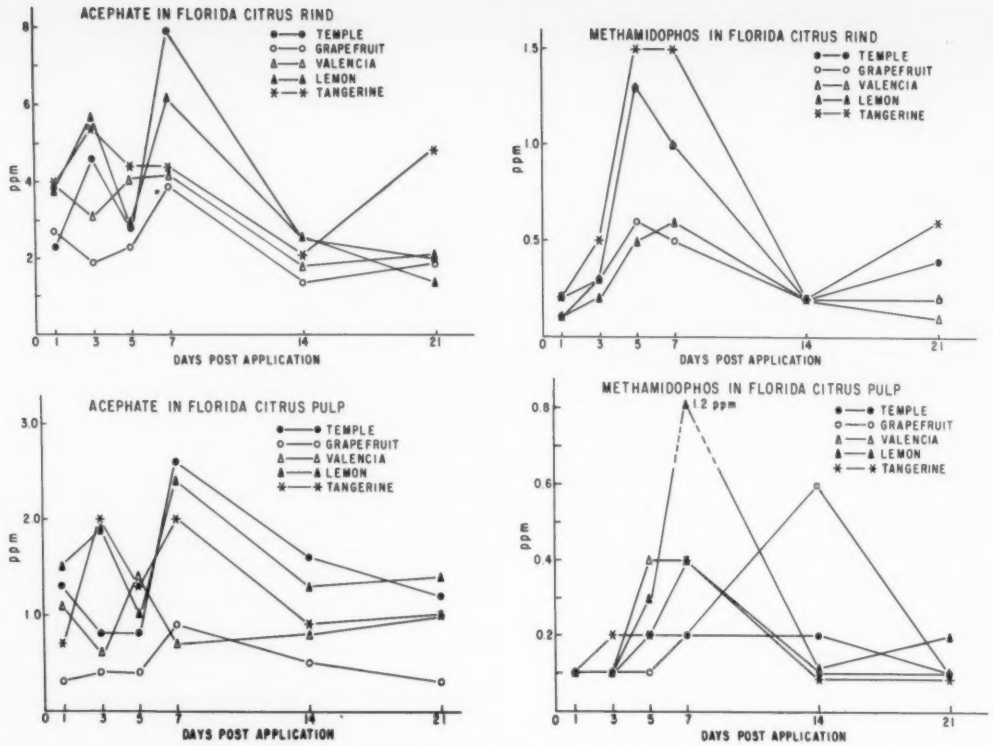

FIGURE 1. *Acephate and methamidophos residue in rind and pulp of Florida citrus. Points for days 1, 3, 5, and 7 are averages of eight determinations. Days 14 and 21 are averages of four determinations.*

TABLE 2. *Methamidophos residues in rind and pulp of Florida citrus, 1976*

	Day, Post Application					
	1	3	5	7	14	21
	Residues (Mean ± Std Dev.), ppm					
Temple orange						
Rind	0.2 ± tr	0.3 ± 0.4	1.3 ± 1.1	1.0 ± 0.5	0.2 ± 0.1	0.4 ± 0.2
Pulp	0.1 ± tr	0.1 ± tr	0.2 ± 0.2	tr	0.2 ± 0.1	0.1 ± 0.2
Grapefruit						
Rind	0.1 ± 0.1	0.3 ± 0.2	0.6 ± 0.5	0.5 ± 0.3	0.2 ± 0.1	0.2 ± tr
Pulp	ND	0.1 ± 0.1	0.1 ± 0.2	0.2 ± 0.3	0.6 ± tr	0.1 ± 0.1
Valencia orange						
Rind	0.2 ± 0.1	0.3 ± 0.3	1.3 ± 0.6	1.0 ± 0.8	0.2 ± 0.1	0.2 ± 0.1
Pulp	0.1 ± 0.2	0.1 ± 0.1	0.4 ± 0.1	tr	0.1 ± 0.1	0.1 ± 0.1
Lemon						
Rind	0.1 ± 0.1	0.2 ± 0.2	0.5 ± 0.3	0.6 ± 0.6	0.2 ± 0.1	0.1 ± 0.1
Pulp	tr	0.1 ± 0.1	0.3 ± 0.6	1.2 ± 1.8	0.1 ± 0.1	0.2 ± 0.1
Tangerine						
Rind	0.2 ± 0.2	0.5 ± 0.4	1.5 ± 1.2	1.5 ± 1.2	0.2 ± 0.1	0.6 ± 0.4
Pulp	tr	0.2 ± 0.2	0.2 ± 0.2	0.4 ± 0.4	0.1 ± tr	0.1 ± 0.1

NOTE: tr = trace = <0.01 ppm. ND = not detected.

washed fruit (days 1, 3, 5, 7), and data for washed and unwashed fruit were combined for statistical analyses. This result may be due to the method of handling samples (*3*). In the present study, frozen fruits were thawed before being peeled. Condensation on the fruits collected in the bottom of the bag; this condensate was not added to the extract because only half of each fruit was peeled. The fruits were thus washed by condensation prior to peeling. This accounts for the absence of statistical difference between washed and unwashed fruits. The data presented here can only properly be considered penetrated residues. Also, no residues of acephate or methamidophos were detected in fruit which had been misted. Only the results of the hydraulic application are reported here.

Both acephate and methamidophos are systemic insecticides, and the data in Figure 1 indicate that at least acephate readily penetrates the rind of all citrus varieties. Because methamidophos can be produced from acephate by hydrolysis, internal methamidophos could have come from acephate.

The peak of penetrated residues of both compounds occurs on days 5 and 7. Acephate residues in rind are significantly higher (0.01 ppm) on day 7 than on days 5 and 14 for Temple oranges, grapefruit, and lemons. For Valencia oranges and tangerines, day 14 residues are significantly lower than are day 7 residues, but due to the variability of the data, the peak of penetrated residues may have occurred on day 5 (Table 1). Had data been taken on day 9, higher methamidophos resi-

dues might have been found, indicating additional conversion of acephate. The data do show, however, that the residues are above the EPA action levels of 3.0 ppm acephate and 0.25 ppm methamidophos on day 7 (Tables 1, 2; Fig. 1).

The acephate-in-pulp pattern is similar to that in rind. Day 7 residues are significantly higher than are residues on days 5 or 14 in Temple oranges, grapefruit, lemons, and tangerines. For Valencia oranges, the peak of acephate in pulp may have occurred on day 5 when residues of acephate were significantly higher than on days 3 or 7. Acephate in pulp was never above the action level of 3.0 ppm. The maximum level of acephate in pulp was 2.0 ppm in tangerines on day 14. Most pulp acephate residues averaged 1.0 ppm or less (Table 1).

The pattern of methamidophos residues was similar to that of acephate (Table 2). For Temple orange, grapefruit, Valencia orange, lemon, and tangerine rind, day 7 residues were significantly higher than were day 14 residues. However, methamidophos levels in rind were the same on days 5 and 7, so residues may have peaked on day 5. In pulp, no peak of methamidophos residues was apparent in Temple oranges, but statistically significant peaks occurred on day 7 in lemons and tangerines, on day 5 in Valencia oranges, and on day 14 in grapefruit.

The pattern of penetration of acephate and methamidophos in both rind and pulp of these varieties was statistically significant and consistent. The peak penetrated residues of acephate and methamidophos in rind and in pulp occurred on or before day 7 with decreasing residues thereafter.

The statistical comparison of varieties in Table 3 indicates that by day 14 there are no differences in acephate residue levels in rind among varieties. Before day 14, no consistent pattern of residue levels is evident. The same comparison for acephate in pulp (Table 4) points to significantly lower residues in grapefruit pulp than in lemon and tangerine pulp. With this exception, there were no differences in acephate residues in pulp by day 21. Residues in Temple oranges were significantly higher than were residues in grapefruit until day 21 (Tables 1, 4).

By day 14 there were no significant differences in methamidophos levels in rind among varieties, yet differences appear on day 21 (Table 5). There were no differences in methamidophos residues in pulp by day 21 (Table 6).

There is a nonrandom source of variation in the comparison of residue levels in citrus which has been noted in greenhouse tomato studies with acephate, surface area–to-weight ratios (*5*).

Confounded with fruit size is varietal rind thickness. Valencia orange rind thickness has been reported as 4.0 mm (*2*), 4.1 mm (*11*), and 3.0 mm (*9*). Marsh grapefruit rind thickness has been noted as 5.5 mm (*11*) and 12.0 mm (*9*). Lemon rind thickness has been reported as 7.3 mm (*11*), 3.6 mm (*1*), and 5.0 mm (*9*). In addition to genetic differences in rind thickness, many climatic and cultural practices affect rind thickness (*1, 2, 9, 11*). In the present experiment, thick grapefruit rind with a low surface area–to-weight ratio appears to account for low pesticide residues in grapefruit. Future experiments to compare citrus variety differences in residue behavior should include rind thickness and surface area measurements to determine

TABLE 3. *Statistical comparison of acephate residue levels in citrus rind, 1976*

	Day, Post Application					
	1	3	5	7	14	21
Temple orange vs. grapefruit	no	yes	no	yes	no	no
Temple vs. Valencia oranges	yes	yes	no	no	no	no
Temple orange vs. lemon	yes	no	no	no	no	no
Temple orange vs. tangerine	yes	no	yes	yes	no	no
Grapefruit vs. Valencia orange	yes	yes	yes	no	no	no
Grapefruit vs. lemon	yes	yes	no	yes	no	no
Grapefruit vs. tangerine	no	yes	yes	no	no	no
Valencia orange vs. lemon	no	yes	no	yes	no	no
Valencia orange vs. tangerine	no	yes	no	no	no	no
Lemon vs. tangerine	no	no	yes	yes	no	yes

NOTE: Yes = means are statistically different at 0.01 level; no = means are not statistically different at 0.01 level (*10*).

TABLE 4. *Statistical comparison of acephate residue levels in citrus pulp, 1976*

	Day, Post Application					
	1	3	5	7	14	21
Temple orange vs. grapefruit	yes	yes	yes	yes	yes	no
Temple vs. Valencia oranges	no	no	yes	yes	yes	no
Temple orange vs. lemon	no	yes	no	no	no	no
Temple orange vs. tangerine	yes	yes	yes	yes	yes	no
Grapefruit vs. Valencia orange	yes	no	yes	no	yes	no
Grapefruit vs. lemon	yes	yes	yes	yes	yes	yes
Grapefruit vs. tangerine	yes	yes	yes	yes	yes	yes
Valencia orange vs. lemon	no	yes	yes	yes	no	no
Valencia orange vs. tangerine	yes	yes	no	yes	no	no
Lemon vs. tangerine	yes	no	no	no	no	no

See NOTE, Table 3.

TABLE 5. *Statistical comparison of methamidophos residue levels in citrus rind, 1976*

	Day, Post Application					
	1	3	5	7	14	21
Temple orange vs. grapefruit	yes	no	yes	yes	no	yes
Temple vs. Valencia oranges	no	no	no	no	no	yes
Temple orange vs. lemon	yes	no	yes	yes	no	yes
Temple orange vs. tangerine	no	no	no	yes	no	no
Grapefruit vs. Valencia orange	yes	no	yes	yes	no	no
Grapefruit vs. lemon	no	no	no	no	no	yes
Grapefruit vs. tangerine	yes	yes	yes	yes	no	yes
Valencia orange vs. lemon	yes	no	yes	yes	no	no
Valencia orange vs. tangerine	no	yes	no	no	no	yes
Lemon vs. tangerine	yes	yes	yes	yes	no	yes

See NOTE, Table 3.

TABLE 6. *Statistical comparison of methamidophos residue levels in citrus pulp, 1976*

	Day, Post Application					
	1	3	5	7	14	21
Temple orange vs. grapefruit	yes	no	no	yes	yes	no
Temple vs. Valencia oranges	no	no	yes	no	no	no
Temple orange vs. lemon	yes	no	no	yes	no	no
Temple orange vs. tangerine	yes	yes	no	yes	yes	no
Grapefruit vs. Valencia orange	yes	no	yes	yes	yes	no
Grapefruit vs. lemon	yes	no	no	yes	yes	no
Grapefruit vs. tangerine	yes	yes	no	yes	yes	no
Valencia orange vs. lemon	yes	no	no	yes	no	no
Valencia orange vs. tangerine	yes	yes	yes	yes	no	no
Lemon vs. tangerine	no	yes	no	yes	no	no

See NOTE, Table 3.

whether any differences in residue levels could be due to fruit structure.

Penetration of both compounds into rind and pulp complicates data analyses. The overall data actually show that the appearance of residue is due to penetration. The fit to a first-order disappearance model is correspondingly poor, ranging from a low of $r = 0.02$ for acephate in Valencia pulp to a high of $r = -0.79$ for acephate in lemon rind. However, when data from days 7 (maximum concentration), 14, and 21 are used, disappearance is clearer (Fig. 1).

There are still positive correlations for methamidophos in Temple and Valencia orange pulp which reflect an appearance of the compound in the pulp, and the tangerine rind data for acephate do not fit a first-order model. Based on 7-, 14-, and 21-day data the half-life averages are 10.5 days and 10.3 days for methamidophos and acephate, respectively, in fruit rind, and 6.1 days and 15.0 days for methamidophos and acephate, respectively, in pulp (Table 7).

The data presented for acephate and methamidophos show that both compounds disappear under Florida conditions after reaching maximum penetrated residues on day 7. Acephate was below 3 ppm in rind 14 days after application and never reached 3 ppm in pulp. Penetrated residues of methamidophos reached an average level of less than 0.25 ppm 21 days after application.

TABLE 7. *Acephate and methamidophos first-order disappearance in Florida citrus, 7–21-day data, 1976*

	Slope		$t_{1/2}$[1] (half-life, days)		r	
	Metha-midophos	Ace-phate	Metha-midophos	Ace-phate	Metha-midophos	Ace-phate
Temple orange						
Rind	−0.07	−0.10	9.9	6.9	−0.57[2]	−0.94[3]
Pulp	0.32	−0.06	2.2	11.6	−0.79[2]	−0.98[3]
Grapefruit						
Rind	−0.07	−0.05	9.9	13.9	−0.86[2]	−0.68[2]
Pulp	−0.05	−0.08	13.9	8.7	−0.38	−0.99[3]
Valencia orange						
Rind	−0.05	−0.05	13.9	13.9	−0.68[2]	−0.77[2]
Pulp	0.32	0.03	2.2	23.1	0.86[3]	0.99[3]
Lemon						
Rind	−0.08	−0.11	8.7	6.3	−0.99[3]	−0.99[3]
Pulp	−0.13	−0.04	5.3	17.3	−0.69[2]	−0.81[2]
Tangerine						
Rind	−0.07	—	9.9	—	−0.45	—
Pulp	−0.10	−0.05	6.9	13.9	−0.87[2]	−0.79[2]
Averages						
Rind			10.5	10.3		
Pulp			6.1	15.0		

[1] $t_{1/2} = \ln(0.5)/\text{slope}$.

[2] Significant at 5 percent level (6).

[3] Significant at 1 percent level or higher (6).

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FISH, WILDLIFE, AND ESTUARIES

Effects of Organochlorine Residues on Eggshell Thickness, Reproduction, and Population Status of Brown Pelicans (Pelecanus occidentalis) *in South Carolina and Florida, 1969–76*

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ABSTRACT

Shells of brown pelican (Pelecanus occidentalis) *eggs collected in South Carolina from 1969 through 1975 and in Florida during 1969, 1970, and 1974 were significantly thinner ($P > 0.05$) than eggshells collected before 1947. Thickness of South Carolina eggshells increased in 1975, and mean thickness of eggshells collected in Florida during 1974 was greater than that of eggshells collected during 1969 and 1970, primarily in Gulf Coast colonies.*

Residues of 13 organochlorines were found in eggs and tissues of pelicans found dead during 1974 and 1975, although residues in brains of these specimens were not high enough to cause death. Residues of organochlorines, except PCBs, declined through 1975. PCBs increased in eggs from Atlantic Coast colonies.

Reproductive success and population status of brown pelicans in South Carolina have improved markedly since authors began their studies in 1969. Good reproductive success was reported in 3 of 5 years from 1973 through 1977.

Introduction

This is part of a series of papers on the effects of environmental pollutants on the brown pelican *(Pelecanus occidentalis).* In previous papers, organochlorine residues in brown pelicans have been related to eggshell thinning (*6, 7*), reproductive success (*9*), adult mortality (*5, 10*), population decline (*4*), and possible extirpation of a population in Louisiana (*8*). The objective of the present study is to further explore effects of organochlorines on brown pelicans, particularly the significance of declining residues. Emphasis is placed on data gathered during 1974–76, but data from 1969 onward are used to show trends over 8 years.

Procedures for Sampling, Necropsy, and Field Study

Most procedures have been described in previous papers (*4, 10*). Brief visits were made to brown pelican colonies in South Carolina in 1969, 1970, and 1976 and to Florida colonies in 1969, 1970, and 1974. The two brown pelican nesting colonies in South Carolina, Deveaux Bank and Marsh Island, Cape Romain National Wildlife Refuge (CRNWR), were studied intensively in the spring and summer each year from 1971 through 1975. Censuses were made of total nests and fledged young in both South Carolina colonies from 1969 through 1976. However, most accurate data were collected during 1971–75 when a number of visits were made to each colony during each nesting season. Addled and viable eggs in all stages of incubation were collected. One egg was usually taken from each nest selected for sampling. Eggs were weighed and measured, and their contents were placed in chemically cleaned glass bottles and frozen. Eggshells were thoroughly washed with tap water and allowed to dry. Shell thickness (shell plus shell membranes) was measured at three sites on the waist of the egg with a micrometer graduated in units of 0.01 mm.

Nests with full clutches and nests from which one egg was collected were marked on Marsh Island to determine their success. Marked nests were checked for eggs or young on each visit to the colony; colonies were visited twice a week for up to 1 hour.

Several dead pelicans and samples of fish regurgitated by pelicans were collected and frozen. The pelicans were removed from the freezer several months later,

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thawed, and subsequently necropsied. Tissues for histological study were fixed in 10 percent formalin, embedded in paraffin, sectioned, and stained. The entire brain was removed and placed in a chemically cleaned glass bottle, and the carcass, except for skin, feet, wings, liver, kidney, and gastrointestinal tract, was wrapped in foil and refrozen. Brains and carcasses were later analyzed for organochlorine residues.

Analytical Procedures

The contents of eggs collected during 1969–71 were homogenized. A 20-g portion was mixed with anhydrous sodium sulfate in a blender and extracted for 7 hours with hexane in a Soxhlet apparatus. The extract was cleaned by acetonitrile partitioning and was eluted on partly deactivated Florisil. For pesticide analyses, residues in the cleaned extract were separated and removed in four fractions from a silica gel thin-layer plate (*17*). Each thin-layer fraction was analyzed by electron-capture gas chromatography (GC) on a column of 3 percent OV-1 or 3.8 percent UCW-98 on Chromosorb W-HP. ΣDDT in fractions III or IV was confirmed on a column of 3 percent XE-60 or 3 percent QF-1 Gas-Chrom Q. Polychlorinated biphenyls (PCBs) were identified and measured semiquantitatively by thin-layer chromatography (*16*). Average recoveries of organochlorine pesticides and their metabolites were 75–112 percent.

Methodology was modified for eggs collected from 1972 to 1975 (*11*). The extract of the 10-g portion was cleaned on a Florisil column. Pesticides and PCBs were separated into three fractions on a Silicar column and analyzed by GC on a column packed with a mixture of 4 percent SE-30 and 6 percent QF-1. This methodology enabled authors to detect toxaphene, *cis*-chlordane, and/or *trans*-nonachlor, and *cis*-nonachlor. Until 1973, there was neither a *cis*-nonachlor standard for quantification nor a procedure to estimate toxaphene levels. Lipids were removed from the eggs collected during 1974–75 either by Florisil cleanup or by automated gel permeation chromatography. In 1974, *cis*-chlordane and *trans*-nonachlor were separated and quantified by changing the column packing to a mixture of 1.5 percent OV-17 and 1.95 percent QF-1.

Residues in about 10 percent of the samples were confirmed by combined gas chromatography–mass spectrometry (GC–MS). Average recoveries from spiked chicken eggs were 81–110 percent; residues are not corrected for recovery values. The lower limit of detection for pesticides or their metabolites was 0.01 μg/g in fish and 0.10 μg/g in other samples (0.01 μg/g for hexachlorobenzene). The lower limit for PCBs was 0.05 μg/g in fish and 0.50 μg/g in other samples.

Results

REPRODUCTIVE SUCCESS AND POPULATION STATUS

From 1969 through 1972 (*10*) and for previous years (*3*), reproductive success of South Carolina pelicans was below the recruitment standard of 1.2–1.5 fledged young per breeding female per year that is necessary to maintain a stable population (*14*). Following a successful reproductive season in 1973, pelicans experienced poor success in 1974 and 1975, then had successful reproductive seasons in 1976 (Table 1) and 1977 (Vivian Mendenhall, Fish and Wildlife Service, U.S. Department of the Interior, 1977: personal communication).

Except in 1969, reproductive success was higher on Deveaux Bank than on Marsh Island (Table 1). However, there was a significant positive correlation ($r = 0.797$, $P < 0.05$) between young fledged per nest in the two colonies over the 8 years considered in the present report. Thus reproductive success in one colony paralleled that in the other colony. Lower reproduction on Marsh Island was attributed to tidal flooding of nests each year, a rare occurrence on Deveaux Bank. Many of the pelicans with flooded nests laid a second clutch, but replacement clutches also were frequently laid in low areas that were eventually flooded.

The size of the breeding population of brown pelicans in South Carolina slowly increased from 1969 through 1974 and then increased 41 percent from 1974 to 1975 as follows: 1,266 pairs in 1969; 1,670 pairs in 1974; 2,400 pairs in 1975; and 3,300 pairs in 1977.

TABLE 1. *Reproductive success of brown pelicans in South Carolina, 1969–76*

Year	Colony	No. of Nests	No. of Young Fledged	Young Fledged per Nest
1969	Cape Romain	1016	900[1]	0.82[1]
	Deveaux Bank	250[1]	80	0.32[1]
	Both Colonies	1266	980	0.78
1970	Cape Romain	637	500[1]	0.78[1]
	Deveaux Bank	479	445	0.93
	Both Colonies	1116	945	0.85
1971	Cape Romain	1094	949	0.87
	Deveaux Bank	375	400	1.07
	Both Colonies	1469	1349	0.92
1972	Cape Romain	763	514	0.67
	Deveaux Bank	652	456	0.70
	Both Colonies	1415	970	0.69
1973	Cape Romain	836	1082	1.29
	Deveaux Bank	810	1644	2.03
	Both Colonies	1646	2726	1.66
1974	Cape Romain	920	825	0.90
	Deveaux Bank	750	800	1.07
	Both Colonies	1670	1625	0.97
1975	Cape Romain	900	500	0.56
	Deveaux Bank	1500	1300	0.87
	Both Colonies	2400	1800	0.75
1976	Cape Romain	1440	1399	0.97
	Deveaux Bank	1100[1]	1738[1]	1.58[1]
	Both Colonies	2540	3137	1.23

[1] Estimated numbers—all other figures are based on actual counts.

TABLE 2. *Probable causes of brown pelican mortality, South Carolina, 1974–75*

Year	Sex	Age	Probable Cause of Mortality
1974	F	4 weeks	sacrificed, had subcutaneous emphysema
	F	6 weeks	hemorrhagic enteritis in combination with severe pecking injuries
	F	12 weeks	respiratory problems—apparent air saculitis
	M	8 weeks	sacrificed, bird was near death of diarrhea and excessive fluid in lungs, air sacs, and pericardium
1975	M	adult	hemorrhagic enteritis
	M	adult	hemorrhagic enteritis

MORTALITY

Pelicans died of possible starvation and several diseases. Hemorrhagic enteritis caused the death of at least two of the six adults found dead on Deveaux Bank April 9, 1975 (Table 2). These pelicans apparently had recently migrated to South Carolina. Many brown pelicans that breed in South Carolina winter on the Atlantic Coast of Florida where hemorrhagic enteritis was responsible for many deaths of the birds in 1972 (*10, 20*).

In 1974, a 6-week-old pelican apparently died of hemorrhagic enteritis and severe pecking; the pecking probably occurred when the sick young was attacked by hostile young and adults. A 12-week-old pelican apparently died of respiratory problems including air saculitis. One of two young sacrificed in 1974 (Table 2) was near death, and the other had subcutaneous emphysema, a condition that is rarely fatal (*13*).

Several hundred downy young were found dead on Deveaux Bank in 1974. Little regurgitated food was observed during visits to the colony compared to visits in other years, and except for the usual heavy mortality after hatching, the deaths involved young at least 4 weeks old, an age when food demand rapidly increases.

EGGSHELL THICKNESS

Mean eggshell thickness of brown pelican eggs collected in South Carolina (Table 3) was 10–17 percent less than the pre-1947 mean of 0.557 mm (*1*). The significant increase ($P < 0.05$) in mean shell thickness in 1975, compared to the 6 preceding years, initiated an upward trend extending to 1977 (Vivian Mendenhall: personal communication).

Overall eggshell thickness of pelican eggs in Florida increased slightly from 1969–70 to 1974 (Table 3); it increased markedly in the Gulf Coast colonies and remained unchanged in the Atlantic Coast colonies (Tables 4, 5). Shell thickness of Gulf Coast pelican eggs collected in 1974 averaged just 2 percent less than the pre-1947 mean, whereas Atlantic Coast eggs averaged 11 percent less. There were insufficient data to compare trends in shell thickness in Florida Bay colonies (Table 4). In addition to South Carolina and Florida, eggshell thickness of brown pelicans has been increasing in California (*2*) and Louisiana (*5*).

RESIDUES IN EGGS

PCB and DDE residues made up the bulk of the 13 organochlorines identified in eggs of brown pelicans (Tables 6–8). Residues in pelican eggs in 1974–75 followed the same pattern in each of the two South Carolina colonies: there was a similarity in mean residues of each organochlorine in a given year, there was much individual variation in residues of each organochlorine, and there was a general decline in residues of most organochlorines (Table 9). These patterns and trends were also evident in samples collected from 1969 through 1973 (*4, 10*). Residues of DDE, DDT, and ΣDDT declined steadily from 1969 through 1975, whereas TDE declined steadily to 1973 and then increased somewhat. Dieldrin declined until 1971 and then remained essentially stable through 1975. PCB residues were erratic and followed no definite trend.

From 1969–70 to 1974 (Table 10), there were significant declines ($P < 0.05$) in DDE, TDE, DDT, and ΣDDT in brown pelican eggs from four regions of the southeastern United States; dieldrin decreased significantly ($P < 0.05$) in South Carolina and along the At-

TABLE 3. *Shell thickness of brown pelican eggs, 1969–75, compared to pre-1947 levels*

Eggshell Thickness, mm[1]							
Pre-1947	1969	1970	1971	1972	1973	1974	1975
SOUTH CAROLINA							
0.557 ± A[2]	0.463 ± D	0.461 ± D	0.480 ± C	0.470 ± CD	0.463 ± D	0.469 ± CD	0.499 ± B
0.012 (23)	0.006 (49)	0.007 (38)	0.005 (65)	0.005 (67)	0.003 (104)	0.004 (116)	0.004 (95)
FLORIDA							
0.557 ± A	0.516 ± B	0.511 ± B				0.521 ± B	
0.003 (169)	0.005 (89)	0.004 (144)				0.004 (122)	

[1] Mean ± standard error; sample size in parentheses.
[2] A significant difference among thickness means ($P < 0.05$) is indicated for those means not sharing a common letter. Means were separated by multiple range tests (*12, 15*).

TABLE 4. *Shell thickness of brown pelican eggs from Florida colonies, 1969–70, 1974*

Colony	Eggshell Thickness, mm[1]		
	1969	1970	1974
ATLANTIC COAST			
Port Orange	0.488 ± 0.012 (9)	0.497 ± 0.009 (9)	0.476 ± 0.013 (14)
Crane Island	—	0.491 ± 0.009 (10)	—
Cocoa Beach	0.497 ± 0.011 (10)	0.482 ± 0.019 (10)	0.499 ± 0.010 (15)
Pelican Island	0.499 ± 0.012 (10)	0.498 ± 0.017 (9)	0.499 ± 0.010 (14)
Fort Pierce	0.513 ± 0.012 (6)	0.504 ± 0.009 (9)	0.508 ± 0.011 (8)
FLORIDA BAY			
Nest Key	—	0.532 ± 0.012 (10)	—
Buchanan Key	0.530 ± 0.015 (3)	0.545 ± 0.013 (10)	—
Fanny Key	—	0.523 ± 0.019 (7)	—
Marquesas Key	—	0.541 ± 0.012 (10)	0.523 ± 0.016 (9)
GULF COAST			
Seahorse Key	0.530 ± 0.015 (6)	0.531 ± 0.016 (10)	0.547 ± 0.009 (15)
Tarpon Key	0.509 ± 0.015 (8)	0.487 ± 0.015 (10)	—
Cortez	—	0.502 ± 0.012 (10)	0.534 ± 0.010 (15)
Bird Key	0.559 ± 0.014 (10)	0.517 ± 0.014 (10)	0.549 ± 0.013 (15)
Matlacha Pass	0.522 ± 0.023 (9)	0.504 ± 0.019 (10)	—
Hemp Island	0.516 ± 0.012 (10)	0.519 ± 0.015 (10)	0.549 ± 0.012 (15)

[1] See footnote 1, Table 3.

TABLE 5. *Shell thickness of brown pelican eggs from the Gulf and Atlantic Coasts of Florida, 1969–70, 1974*

Eggshell Thickness, mm[1]		
1969	1970	1974
GULF COAST		
0.528 ± AB[2] 0.007 (43)	0.510 ± A 0.006 (60)	0.545 ± B 0.006 (60)
ATLANTIC COAST		
0.498 ± A 0.006 (35)	0.494 ± A 0.006 (47)	0.494 ± A 0.006 (51)

[1] See footnote 1, Table 3.
[2] See footnote 2, Table 3.

lantic Coast of Florida, remained stable in Florida Bay, and increased slightly on the Gulf Coast. In contrast, PCBs increased significantly ($P < 0.05$) in two areas and showed little change in the other two areas. The most striking change was on the Atlantic Coast of Florida where the PCB residues more than doubled from 1969–70 to 1974. The DDE:PCB ratio changed dramatically in most areas. For example, the ratio was approximately 1:1 on the Atlantic Coast of Florida in 1969–70 and 1:6 in 1974. DDT residues were rarely found in 1974 samples. The order of decreasing organochlorine contamination, by area, in pelican eggs during each sampling period was: South Carolina > Florida Atlantic Coast > Florida Gulf Coast > Florida Bay (Table 10). Eggs collected from the Gulf Coast and Florida Bay colonies in 1974 were essentially devoid of organochlorine residues.

RESIDUES IN TISSUES

Birds found dead were analyzed for organochlorine residues. Residues in tissues of four pre-fledgling pelicans found dead in South Carolina in 1974 were as low as those reported previously in other young pelicans (*4, 10*). Six freshly dead adult pelicans were found on Deveaux Bank April 9, 1975.

Residues in three male adults were much higher than in the young birds collected in 1974, but residues in their brains were below lethal levels (Table 11).

RESIDUES IN FISH

Breeding brown pelicans in South Carolina feed almost exclusively on young-of-the-year Atlantic menhaden (*Breevoortia tyrannus*) that hatch off the coast from October through April and migrate into the estuaries as larvae where they usually remain for 6–8 months (*19*). Residues of DDE in menhaden in 1974 and 1975 were much lower than those reported in 1973 (*10*); DDT and dieldrin were found in most 1973 samples but were not detected in 1974–75 samples (Table 12). PCB residues averaged about the same in 1973 and 1974 but declined substantially in 1975.

Discussion

Because trips to Deveaux Bank were infrequent, it could not be established that starvation was responsible for the deaths of downy young in 1974. Both young that were necropsied exhibited signs of disease that may or may not have been related to starvation (Table 2). There were no apparent deaths of downy young on the CRNWR, about 65 km northeast of Deveaux Bank, although the pelicans there had poor reproductive success and, judging from regurgitated boluses, they preyed on a greater variety of fish than usual. Therefore, poor food supply was probably responsible for the deaths of downy young on Deveaux Bank.

The authors previously suggested that migration of Atlantic menhaden complicate interpretation of biomagnification of residues from fish to pelican eggs (*10*) because adult menhaden are exposed to varying levels of organochlorine residues during migration. However, authors have since determined that breeding pelicans in South Carolina feed almost exclusively on young-of-the-year menhaden that apparently accumulate nearly all their residues from local estuaries. The interpretation of biomagnification is still complicated by the migratory behavior of the brown pelican that exposes it to several habitats with differing degrees of organochlorine pollution.

TABLE 6. *Organochlorine residues in brown pelican eggs, South Carolina, 1974*

RESIDUES, μG/G FRESH WET WEIGHT													
	DDE	TDE	DDT	DIELDRIN	HEPTACHLOR EPOXIDE	MIREX	OXYCHLORDANE	*cis*-CHLORDANE	*trans*-NONACHLOR	*cis*-NONACHLOR	HCB	TOXAPHENE	PCBs
MARSH ISLAND													
	1.89	0.60	—	0.44	—	—	—	0.18	0.19	0.11	—	0.27	5.60
	1.43	0.48	—	0.33	—	—	—	0.15	0.15	—	—	0.12	4.15
	1.37	0.48	—	0.27	—	—	—	—	—	—	—	0.18	5.25
	1.56	0.46	—	0.39	—	0.11	—	0.11	—	—	—	0.11	6.87
	1.70	0.48	—	0.55	—	—	—	0.16	0.15	—	0.10	1.88	7.57
	2.39	0.58	—	0.46	—	—	—	0.19	0.25	0.12	—	0.12	7.98
	1.35	0.46	—	0.30	—	—	—	0.16	0.10	—	—	—	4.34
	1.51	0.38	—	0.40	—	—	—	—	—	—	—	0.21	8.30
	1.65	0.37	—	0.40	—	—	—	0.13	—	—	—	0.22	4.19
	1.65	0.38	—	0.36	—	—	—	0.16	0.13	0.10	—	0.19	7.02
	1.67	0.30	—	0.42	—	—	—	—	—	—	—	0.18	6.90
	1.00	0.32	—	0.27	—	—	—	0.15	0.13	—	—	0.15	5.40
	7.03	1.48	—	1.46	0.14	0.20	—	0.41	0.63	0.35	—	0.83	18.09
	2.46	0.36	—	0.46	—	—	—	0.14	0.21	0.16	—	0.15	13.80
	1.33	0.39	—	0.36	—	—	—	0.15	0.16	—	—	0.21	9.21
	3.83	0.91	—	0.96	0.10	—	—	0.31	0.34	0.22	—	0.38	13.88
	2.36	0.47	—	0.57	—	0.10	—	0.21	0.24	0.18	—	0.29	11.80
	1.37	0.35	—	0.13	—	—	—	0.12	0.15	—	—	0.20	7.66
	1.75	0.42	—	0.28	—	—	—	0.11	0.14	—	—	0.17	17.00
	4.69	1.80	0.58	2.89	0.32	—	0.11	0.61	0.71	0.63	—	—	13.00
	1.95	0.57	—	0.62	—	—	—	0.19	0.17	0.15	—	—	6.49
	2.75	0.60	—	0.73	—	—	—	0.19	0.19	0.25	—	—	10.50
	1.86	0.45	—	0.42	—	—	—	0.16	0.10	0.10	—	—	5.69
	3.42	0.64	—	0.73	—	—	—	0.21	0.11	0.22	—	—	11.70
	1.40	—	—	0.46	—	—	—	0.17	0.13	—	—	—	8.15
	2.94	0.34	—	0.74	—	—	—	—	—	0.15	—	—	12.50
	3.79	—	—	0.88	—	—	—	0.22	0.17	0.31	—	—	7.10
	5.85	0.14	—	1.27	—	—	—	0.36	0.33	0.30	—	—	22.11
	5.51	—	—	1.03	—	—	—	0.35	0.38	0.25	—	—	21.80
	1.22	0.16	—	0.49	—	—	—	—	—	—	—	—	7.34
	2.45	0.41	0.15	0.61	—	—	—	0.13	0.17	0.15	—	—	8.53
	2.82	—	—	0.86	—	—	—	0.14	0.20	0.27	—	—	12.15
	3.80	0.78	—	0.90	—	—	—	0.24	0.24	0.22	—	—	11.65
	4.13	0.59	—	0.83	—	—	—	0.17	0.19	0.18	—	—	9.80
	2.21	0.47	—	0.64	—	—	—	0.17	0.16	0.23	—	—	8.19
	2.38	0.40	—	0.71	—	—	—	0.14	0.13	0.16	—	—	7.38
	5.91	1.25	—	1.21	—	—	0.10	0.40	0.42	0.45	—	—	17.72
	0.81	0.19	—	0.18	—	—	—	0.15	0.11	0.11	—	—	6.39
	3.90	0.68	—	0.71	—	—	—	0.23	0.19	0.11	—	—	8.28
	1.40	0.34	—	0.31	—	—	—	—	—	—	—	0.21	0.70
	3.86	0.63	—	0.84	—	—	—	0.22	0.24	0.17	—	0.46	11.33
	5.57	1.09	0.73	1.26	0.16	0.20	—	0.44	0.39	0.31	—	0.82	14.04
	2.41	0.63	0.34	0.56	—	—	—	0.24	0.22	0.15	—	0.46	7.05
	1.53	0.26	—	0.26	—	—	—	0.11	0.16	—	—	0.17	8.02
	2.38	0.59	—	0.36	—	—	—	0.10	—	0.10	—	0.17	5.47
	5.00	0.90	—	1.10	—	—	—	0.45	0.47	0.45	—	0.57	27.48
	3.04	0.78	—	0.71	—	—	—	0.28	0.28	0.18	—	0.58	14.43
	3.68	0.83	—	0.71	—	—	—	0.27	0.32	0.17	—	0.39	11.77
	2.67	0.49	—	0.36	—	—	—	0.16	0.16	0.14	—	0.23	5.10
	2.99	0.67	—	0.57	—	—	—	0.22	0.30	0.15	—	0.37	9.90
	1.95	0.53	—	0.49	—	—	—	0.14	0.12	0.22	—	0.35	2.30
	1.95	0.36	—	0.38	—	—	—	0.16	0.20	0.12	—	—	8.80
	2.08	0.47	—	0.59	0.10	—	—	0.25	0.23	0.16	—	—	8.00
	1.07	0.23	—	0.26	—	—	—	0.11	0.15	—	—	0.35	5.80
GM	2.35	0.41		0.55				0.17	0.16	0.12		0.13	8.32
CL	2.04–2.70	0.34–0.51		0.47–0.63				0.14–0.20	0.13–0.19	0.10–0.15		0.10–0.17	7.10– 9.76
Range	0.81–7.03	ND–1.80	ND–0.73	0.17–2.89	ND–0.32	ND–0.20	ND–0.11	ND–0.61	ND–0.71	ND–0.63	ND–0.10	ND–1.88	0.70–27.48
DEVEAUX BANK													
	1.50	0.50	—	0.36	—	—	—	0.11	0.09	—	—	0.32	5.01
	1.27	0.38	—	0.33	—	—	—	0.10	—	—	—	0.20	5.16
	0.65	0.36	—	0.34	—	—	—	—	—	—	—	0.22	4.07
	1.36	0.37	—	0.29	—	—	—	0.14	0.13	0.09	—	0.21	5.00
	1.48	0.38	—	0.33	—	0.30	—	—	—	—	—	—	1.90
	1.84	0.48	—	0.45	—	—	—	0.09	0.21	0.09	—	—	8.14
	1.48	0.47	—	0.45	—	—	—	—	0.18	—	—	—	7.53
	1.93	0.56	—	0.59	—	—	—	0.22	0.12	—	—	—	12.00
	0.89	0.22	—	0.26	—	—	—	—	0.14	—	—	—	4.24
	2.44	0.76	—	0.66	—	0.20	—	0.23	0.19	0.15	—	—	11.07
	2.70	0.61	—	0.81	—	—	—	0.18	0.19	0.15	—	—	9.82
	2.18	0.40	0.11	0.62	—	—	—	0.17	0.23	—	—	—	12.16
	1.20	0.34	—	0.26	—	—	—	—	0.17	—	—	—	4.80
	2.30	0.59	—	0.54	0.16	—	—	0.11	0.22	0.10	—	—	7.58

(Continued next page)

TABLE 6 (Cont'd.) *Organochlorine residues in brown pelican eggs, South Carolina, 1974*

	Residues, μg/g fresh wet weight												
	DDE	TDE	DDT	Dieldrin	Heptachlor Epoxide	Mirex	Oxychlordane	*cis*-Chlordane	*trans*-Nonachlor	*cis*-Nonachlor	HCB	Toxaphene	PCBs
	1.40	0.34	—	0.36	—	—	—	0.11	0.12	—	—	—	5.37
	2.50	—	—	0.73	—	—	—	—	0.13	—	—	—	8.84
	3.53	0.95	—	0.95	—	0.13	—	0.31	0.24	0.24	—	—	16.76
	2.29	0.37	—	0.56	—	—	—	0.12	0.16	0.14	—	—	12.90
	2.42	0.59	—	0.61	—	—	—	0.16	0.16	0.14	—	—	8.27
	2.99	0.69	0.10	0.83	—	—	—	0.23	0.41	0.21	—	—	17.00
	1.70	0.46	—	0.50	—	—	—	0.21	0.26	0.18	—	—	7.91
	1.72	0.37	—	0.39	—	—	—	0.12	0.27	0.11	—	—	9.58
	1.60	0.31	—	0.39	—	—	—	0.15	0.19	0.13	—	—	7.50
	2.19	0.50	—	0.59	0.26	—	0.53	0.12	0.83	0.22	—	—	12.71
	1.65	0.43	—	0.43	—	—	—	0.16	0.19	0.11	—	0.17	4.74
	2.08	0.45	—	0.61	—	—	—	0.20	0.28	0.19	—	—	3.07
	2.02	0.52	—	0.47	—	—	—	0.19	0.25	0.13	—	—	7.18
	1.15	0.42	—	0.44	—	—	—	0.21	0.24	0.14	—	—	5.51
	1.43	0.42	—	0.42	—	—	—	0.17	0.17	0.10	—	—	8.02
	2.87	0.48	—	0.60	—	—	—	0.24	0.29	0.22	—	0.24	6.47
	2.11	0.37	—	0.55	—	—	—	0.16	0.15	0.16	—	0.76	5.70
	1.36	0.21	—	0.29	—	—	—	0.18	0.23	0.14	—	—	5.96
	1.37	0.31	—	0.60	—	—	—	0.31	0.24	0.20	—	—	1.32
	0.74	0.23	—	0.22	—	—	—	0.11	0.10	0.10	—	—	0.62
	0.78	0.16	—	0.32	—	—	—	—	—	—	—	—	0.95
	0.76	0.21	—	0.19	—	—	—	0.10	—	—	—	—	2.18
	1.41	0.22	0.20	0.27	—	—	—	0.14	0.16	0.10	—	—	3.17
	2.35	0.10	—	1.28	0.11	—	—	0.45	0.25	0.23	—	0.24	2.20
	0.80	0.27	—	0.27	—	—	—	0.14	0.13	0.13	—	0.39	5.35
	2.18	0.39	—	0.44	—	—	—	0.18	0.15	0.14	—	0.41	6.04
	2.05	0.37	—	0.56	—	—	—	0.16	0.12	0.13	—	0.41	2.68
	2.16	0.96	0.18	0.86	—	0.10	—	—	0.18	0.19	—	0.49	4.91
	1.84	0.48	—	0.39	—	—	—	0.29	0.14	0.24	—	0.31	6.54
	4.51	0.95	—	1.10	0.13	0.17	—	0.41	0.32	0.33	—	0.74	9.90
	3.04	0.84	—	1.14	0.12	—	—	0.41	0.30	0.25	—	0.48	14.18
	3.76	0.73	0.19	0.80	—	—	—	0.33	0.27	0.29	—	0.57	15.48
	3.11	0.62	—	0.53	—	—	—	0.29	0.31	0.20	—	—	5.27
	1.98	0.45	—	0.54	—	—	—	0.17	0.14	0.10	—	0.26	3.30
	2.12	0.31	—	0.33	—	—	—	0.12	0.12	0.10	—	0.14	8.11
	1.96	0.51	—	0.54	—	—	—	0.24	0.12	0.13	—	0.22	5.88
	1.92	0.62	0.10	0.67	0.11	—	—	0.29	0.24	0.15	—	—	5.80
	2.33	0.44	—	0.61	—	—	—	0.15	0.18	0.14	—	0.21	7.70
	3.32	0.59	—	0.88	0.12	—	—	0.20	0.21	0.19	—	—	9.50
	4.62	0.92	0.11	1.43	0.23	—	—	0.44	0.42	0.32	—	—	19.40
	4.94	1.22	—	1.22	0.14	3.01	—	0.45	0.40	0.35	0.02	0.73	21.40
	3.59	0.76	—	0.84	—	0.33	—	0.26	0.33	0.23	0.02	0.41	12.40
	3.67	0.37	—	0.85	0.11	—	—	0.22	0.22	0.18	0.02	—	12.60
	2.98	0.69	—	0.71	0.10	0.21	—	0.30	0.25	0.20	0.01	0.16	11.50
	1.59	0.38	—	0.40	—	—	—	0.22	0.14	0.13	0.01	0.18	8.80
	4.48	0.96	—	0.85	0.10	0.25	—	0.36	0.34	0.25	0.02	0.49	14.30
	2.30	0.80	—	0.96	0.13	—	—	0.50	0.21	0.37	0.04	0.41	24.80
GM	1.96	0.45		0.53				0.17	0.18	0.13		0.11	6.59
CL	1.74–2.21	0.40–0.52		0.47–0.60				0.14–0.19	0.16–0.21	0.11–0.15		0.09–0.14	5.48– 7.94
Range	0.65–4.94	ND–1.22	ND–0.20	0.19–1.43	ND–0.26	ND–3.01	ND–0.53	ND–0.50	ND–0.83	ND–0.37	ND–0.04	ND–0.76	0.62–24.80
MARSH ISLAND AND DEVEAUX BANK													
GM	2.13	0.44		0.54				0.17	0.17	0.13		0.12	7.36
CL	1.95–2.34	0.39–0.49		0.49–0.59				0.15–0.19	0.15–0.19	0.11–0.14		0.10–0.14	6.50– 8.32
Range	0.65–7.03	ND–1.80	ND–0.73	0.17–2.89	ND–0.32	ND–3.01	ND–0.53	ND–0.61	ND–0.83	ND–0.63	ND–0.10	ND–1.88	0.62–27.48

NOTE: ND or — = no residue detected.
GM = geometric mean.
CL = 95 percent confidence limits.

TABLE 7. *Organochlorine residues in brown pelican eggs, South Carolina, 1975*

Residues, μg/g fresh wet weight												
	DDE	TDE	DDT	Dieldrin	Heptachlor Epoxide	Mirex	Oxy-chlordane	*cis*-Chlordane	*trans*-Nona-chlor	*cis*-Nona-chlor	Toxaphene	PCBs
MARSH ISLAND												
	1.41	0.38	—	0.50	—	—	—	0.13	—	0.15	0.38	5.02
	1.04	0.30	—	0.22	—	—	—	0.11	0.13	—	0.28	3.01
	1.91	0.75	—	0.58	—	0.10	—	0.29	0.27	0.24	0.27	4.35
	1.68	0.37	—	0.44	—	—	—	0.15	0.14	0.10	0.32	3.95
	1.15	0.27	—	0.34	—	—	—	0.15	0.13	0.11	0.24	4.64
	1.84	0.33	0.13	0.36	0.10	—	0.12	0.33	0.23	0.29	0.57	7.40
	1.00	0.35	—	0.32	—	—	—	0.17	0.19	0.13	0.24	3.28
	1.61	0.53	—	0.50	—	—	—	0.15	—	0.09	0.43	3.36
	3.10	0.69	—	0.72	—	—	—	0.26	0.24	0.19	0.31	10.03
	1.53	0.26	—	0.36	—	—	—	—	0.10	—	0.48	3.10
	1.20	0.33	—	0.35	—	—	—	0.17	0.18	0.11	0.48	4.50
	1.10	0.18	—	0.23	—	—	—	—	0.13	—	—	5.31
	1.22	0.31	—	0.31	—	—	—	0.12	0.16	—	0.14	6.45
	2.59	0.49	—	0.66	—	—	—	0.18	0.26	0.19	0.49	11.05
	1.64	0.41	—	0.48	—	—	—	0.20	0.26	0.18	0.55	6.20
	1.20	0.34	—	0.27	—	—	—	0.12	0.16	—	0.14	5.20
	0.81	0.19	—	0.22	—	—	—	0.10	0.10	—	0.11	8.80
	1.44	0.59	—	0.38	—	—	—	0.25	0.25	0.13	0.18	6.98
	1.09	0.34	—	0.27	—	—	—	0.14	0.18	0.10	0.16	5.02
	1.42	0.50	—	0.34	—	—	—	0.18	0.25	0.13	0.15	6.31
	1.03	0.34	—	0.27	—	—	—	0.19	0.15	0.11	0.21	5.95
	1.10	0.34	—	0.24	—	—	—	—	0.15	—	0.22	4.87
	0.75	0.30	—	0.16	—	—	—	0.11	—	—	0.16	7.06
	0.65	0.21	—	0.17	—	—	—	0.10	0.11	—	0.41	6.92
	0.96	0.31	—	0.26	—	—	—	0.16	0.18	0.12	0.16	8.73
	0.88	0.21	—	0.22	—	—	—	—	—	—	0.16	7.33
	1.61	0.57	—	0.38	—	—	—	0.25	0.14	0.14	0.26	8.38
	1.73	0.64	—	0.45	—	—	—	0.31	0.24	0.15	0.22	10.89
	1.13	0.34	—	0.34	—	—	—	0.16	0.14	0.11	0.21	7.96
	1.50	0.37	—	0.37	—	—	—	0.17	0.18	0.14	0.21	14.40
	1.91	0.58	—	0.53	—	0.10	—	0.31	0.22	0.20	0.34	12.78
	1.34	0.38	—	0.30	—	—	—	0.17	0.19	0.12	0.20	9.84
	1.57	0.54	—	0.51	—	0.14	—	0.24	0.16	0.14	0.42	12.96
	1.64	0.47	—	0.55	—	—	—	0.27	0.17	0 23	0.27	13.46
	1.12	0.41	—	0.32	—	—	—	0.21	0.19	0.13	0.20	10.72
	0.70	0.34	—	0.22	—	—	—	0.18	0.16	0.11	0.15	9.85
	1.57	0.41	—	0.51	—	—	—	0.22	0.16	0.16	0.28	12.91
	0.36	0.10	—	0.10	—	—	—	—	—	—	—	5.23
	0.87	0.29	—	0.23	—	—	—	0.13	0.14	—	—	5.81
	1.76	0.62	—	0.41	—	—	—	0.25	0.21	0.18	0.27	14.89
	1.15	0.45	—	0.34	—	—	—	0.23	0.13	0.14	0.12	6.46
	0.70	0.20	—	0.19	—	—	—	—	—	—	—	4.70
	0.95	—	—	0.23	—	—	—	0.14	0.10	0.14	0.11	11.53
	1.71	0.39	—	0.43	—	—	—	0.19	0.15	0.19	0.21	12.32
	1.85	0.60	—	0.53	—	—	—	0.25	0.14	0.20	0.37	14.53
	2.76	0.74	—	0 76	0.11	0.27	—	0.31	0.29	0.31	0.27	13.91
	1.65	0.57	—	0.42	—	—	—	0.26	0.18	0.18	0.21	9.67
	0.89	0.37	—	0.28	—	—	—	0.15	—	0.11	0.23	7.57
	1.72	0.67	—	0.92	—	—	0.13	0.67	0.35	0.40	0.40	12.93
	0.95	0.21	—	0.26	—	—	—	0.16	0.98	0.16	0.14	12.31
	1.80	0.38	—	0.40	—	—	—	0.17	0.16	0.18	0.29	17.99
	1.08	0.42	—	0.28	—	—	—	0.17	0.15	0.11	0.14	6.57
	2.51	0.58	—	0.71	0.10	0.38	—	0.39	0.23	0.33	0.33	20.08
	2.36	0.65	—	0.67	—	—	—	0.28	0.19	0.19	0.31	10.81
	1.58	0.43	—	0.49	—	0.10	—	0.21	0.12	0.13	0.27	7.43
	1.60	—	—	0.50	—	—	—	—	—	—	—	1.40
	0.18	—	—	—	—	—	—	—	—	—	—	0.38
	2.00	0.81	—	0.50	—	—	—	0.31	0.33	0.19	0.50	7.47
	1.59	0.58	—	0.40	—	—	—	0.28	0.28	0.17	0.29	10.95
GM	1.30	0.36		0.35				0.16	0.15	0.12	0.21	7.23
CL	1.15–1.46	0.30–0.42		0.31–0.40				0.14–0.19	0.13–0.18	0.10–0.14	0.18–0.25	6.13– 8.52
Range	0.18–3.10	ND–0.81	ND–0.13	ND–0.92	ND–0.11	ND–0.38	ND–0.13	ND–0.67	ND–0.98	ND–0.40	ND–0.57	0.38–20.08
DEVEAUX BANK												
	1.24	0.36	—	0.39	—	—	—	0.19	0.10	0.12	0.22	1.77
	3 03	0.68	—	0.63	—	0.19	—	0.15	0.11	0.15	0.54	1.84
	1.70	0.37	—	0.40	—	—	—	0.15	0.17	0.12	0.22	3.49
	2.51	0.91	—	0.55	—	—	—	0.25	0.17	0.13	0.50	7.32
	1.34	0.37	—	0.41	—	—	—	0.16	0.15	0.12	0.13	2.60
	1.35	0.32	—	0.34	—	—	—	0.13	0.14	0.12	0.24	2.69
	2.03	0.54	—	0.59	—	—	—	0.19	0.19	0.16	0.40	3.96
	0.91	0.33	—	0.21	—	—	—	0.14	—	—	0.11	2.51
	1.34	0.41	—	0.29	—	—	—	0.17	—	0.10	0.21	2.43
	0.39	—	—	—	—	—	—	—	0.09	—	—	1.70

(Continued next page)

TABLE 7 (cont'd.). *Organochlorine residues in brown pelican eggs, South Carolina, 1975*

	Residues, µg/g fresh wet weight											
	DDE	TDE	DDT	Dieldrin	Heptachlor Epoxide	Mirex	Oxychlordane	*cis*-Chlordane	*trans*-Nonachlor	*cis*-Nonachlor	Toxaphene	PCB
	0.65	0.11	—	0.11	—	—	0.13	0.13	0.11	0.07	0.09	6.82
	—	0.29	—	0.34	—	—	—	0.17	0.24	0.16	0.22	3.92
	0.10	0.80	—	0.64	—	—	—	0.29	0.29	0.18	0.31	4.20
	1.02	0.26	—	0.28	—	—	—	0.14	0.19	—	0.11	3.07
	1.62	0.45	—	0.40	—	—	—	0.16	0.20	0.14	0.38	3.60
	0.88	0.31	—	0.21	—	—	—	0.17	—	—	0.18	1.54
	3.69	0.10	—	0.97	—	—	—	0.59	—	0.35	0.35	5.93
	1.00	0.34	—	0.27	—	0.10	—	0.12	—	—	0.22	1.98
	1.52	0.41	—	0.97	—	0.14	—	0.15	0.27	0.11	0.36	3.63
	0.50	—	—	0.11	—	—	—	—	—	—	0.21	4.37
	1.78	0.60	—	0.44	—	—	—	0.24	0.33	0.18	0.58	13.56
	1.48	0.35	—	0.29	—	—	—	0.16	0.22	0.14	0.31	9.66
	0.97	0.35	—	0.33	—	—	—	0.17	0.19	0.10	0.20	5.55
	1.99	0.52	—	0.39	—	—	—	0.18	0.24	0 14	0.37	7.88
	1.19	0.30	—	0.35	—	—	—	0.13	0.18	0.11	0.40	10.81
	1.02	0.42	—	0.35	0.10	—	—	0.17	0.22	0.11	0.14	8.40
	1.23	0.31	—	0.33	—	—	—	0.15	0.22	0.14	0.10	6.86
	1.59	0.54	—	0.45	—	—	—	0.20	0.27	0.14	0.25	5.19
	1.40	0.38	—	0.34	—	—	—	0.19	0.26	0.14	0.15	9.88
	1.99	0.51	—	0.51	0.12	—	—	0.19	0.27	0 16	0.12	9.86
	2.48	0.72	—	0.46	0.10	—	—	0.23	0.34	0.18	0.27	10.25
	1.00	0.20	—	0.21	—	—	—	0.10	0.12	0.09	—	7.92
	1.73	0.22	—	0.43	—	—	—	0.14	0.19	0.12	—	10.43
	1.28	0.20	—	0.35	—	—	0.10	0.24	0.16	0.09	—	7.22
	0.76	0.23	—	0.20	—	—	—	0.10	0.13	—	0.23	7.93
	2.09	0.38	—	0.53	0.10	—	0.13	0.26	0.28	0.13	0.26	10.03
	3.04	0.58	—	0.40	0.14	—	—	0.96	—	0.20	1.27	11.46
	1.90	0.41	—	0.63	—	—	—	0.46	0.16	0.12	0.09	3.90
	2.91	0.78	—	0.70	0.20	—	—	0.24	—	0.20	1.02	6.06
	3.62	1.38	—	1.04	0.50	—	0.10	0.61	0.68	0.22	0.38	6.11
	1.86	0.44	—	0.46	0.14	—	—	0.13	0.28	0.14	0.51	4.88
	3.13	0.96	—	0.96	0.31	—	—	0.36	0.53	0.31	0.67	10.10
	2.22	0.38	—	0.68	0.21	—	—	0.28	0.40	0.17	0.57	6.37
GM	1.29	0.38		0.38				0.18	0.16	0.12	0.23	5.07
CL	0.99–1.67	0.31–0.47		0.31–0.46				0.16–0.22	0.13–0.20	0.10–0.14	0.18–0.30	4.20– 6.1
Range	ND–3.69	ND–1.38	ND	ND–1.04	ND–0.50	ND–0.19	ND–0.13	ND–0.96	ND–0.68	ND–0.35	ND–1.27	1.54–13.5
	MARSH ISLAND AND DEVEAUX BANK											
GM	1.29	0.36		0.36				0.17	0.15	0.12	0.22	6.24
CL	1.14–1.47	0.32–0.41		0.32–0.40				0.15–0.19	0.14–0.17	0.11–0.13	0.19–0.25	5.50– 7.0
Range	ND–3.69	ND–1.38	ND–0.13	ND–1.04	ND–0.50	ND–0.38	ND–0.13	ND–0.96	ND–0.98	ND–0.40	ND–1.27	0.38–20.0

NOTE: ND or — = no residues detected.
GM = geometric mean.
CL = 95 percent confidence limits.

TABLE 8. *Organochlorine residues in brown pelican eggs, Florida, 1974*

Colony	Residues, µg/g fresh wet weight									
	DDE	TDE	PCBs	Heptachlor Epoxide	Mirex	*cis*-Chlordane	*trans*-Nonachlor	*cis*-Nonachlor	Toxaphene	Dieldrin
GULF COAST										
Cedar Key	—	0.11	0.91	—	—	—	—	—	—	—
	0.16	—	0.36	—	—	—	—	—	—	—
	0.23	—	0.86	—	—	—	—	—	—	—
	0.52	—	1.60	—	—	—	—	—	—	0.10
	0.47	—	1.20	—	—	—	—	—	—	—
	0.29	—	0.56	—	—	—	—	—	—	—
	0.99	0.31	0.75	—	—	0.10	—	—	—	0.14
	0.20	—	0.47	—	—	—	—	—	—	—
	0.64	0.18	1.40	—	—	—	—	—	—	—
	0.42	—	0.65	—	—	0.14	0.12	0.10	—	0.21
	0.24	—	0.69	—	—	—	—	—	—	—
	—	—	0.69	—	—	—	—	—	—	0.16
	—	0.14	0.79	—	—	—	—	—	—	0.58
	—	—	0.44	—	—	—	—	—	—	0.44
	0.24	—	1.10	—	—	—	—	—	—	0.19
GM	0.29		0.80							
CL	0.16–0.43		0.62– 1.00							
Range	ND–0.64	ND–0.31	0.36– 1.60	ND	ND	ND–0.14	ND–0.12	ND–0.10	ND	ND–0.58
Cortez	0.51	0.10	2.10	—	—	0.20	—	0.13	—	0.18
	0.33	—	1.00	—	—	—	—	—	—	0.14
	0.57	0.18	2.00	—	—	0.27	—	0.15	—	0.19
	1.00	0.12	1.80	—	—	—	—	—	—	0.12
	0.64	0.14	1.10	—	—	—	1.00	—	—	0.15
	0.39	0.13	1.10	—	—	0.10	0.13	—	—	0.15
	0.37	0.10	1.00	—	—	0.15	0.19	—	—	0.11
	0.12	0.10	10.30	—	—	—	—	—	—	—
	0.31	—	1.50	—	—	0.33	0.23	0.18	—	0.38
	1.47	0.20	2.20	—	—	0.14	0.17	0.10	—	0.23
	0.35	0.11	0.99	—	—	0.15	0.11	—	—	0.18
	—	0.11	3.90	—	—	0.17	—	—	—	0.10
	0.66	0.22	0.75	—	—	0.19	0.17	0.12	—	0.19
	—	0.15	1.40	—	—	0.29	0.20	0.16	—	0.17
	0.52	0.14	1.20	—	—	0.23	0.19	0.11	—	0.20
GM	0.45	0.12	1.74			0.14	0.14	0.06		0.16
CL	0.28–0.65	0.08–0.15	1.11– 2.57			0.08–0.20	0.04–0.26	0.02–0.10		0.12–0.20
Range	ND–1.47	ND–0.22	0.75–10.30	ND	ND	ND–0.33	ND–1.00	ND–0.18	ND	ND–0.38
Bird Key	0.15	—	0.60	—	—	—	—	—	0.60	—
	0.29	—	0.41	—	—	—	—	—	—	0.11
	0.26	0.10	0.15	—	—	—	—	—	—	0.12
	0.55	0.16	1.70	—	—	0.15	0.16	0.10	—	0.18
	0.57	0.11	1.60	—	—	0.17	0.22	0.13	—	0.25
	—	0.19	0.25	—	—	0.19	—	—	—	—
	0.59	0.13	1.20	—	—	0.10	—	—	—	0.17
	0.30	—	1.00	—	—	0.10	—	—	—	0.13
	0.22	—	0.33	—	—	0.10	—	—	—	0.11
	0.33	0.13	3.20	—	—	—	—	—	—	0.15
	0.20	—	1.20	—	0.31	0.17	—	—	—	0.10
	—	—	1.20	—	0.10	0.09	—	—	—	—
	0.31	0.14	2.80	—	—	—	—	—	—	0.19
	0.22	—	1.50	—	0.19	—	—	0.11	—	—
	0.12	—	0.51	—	—	—	—	—	0.44	—
GM	0.27	0.06	1.02			0.07				0.10
CL	0.18–0.37	0.02–0.10	0.63– 1.51			0.03–0.11				0.07–0.14
Range	ND–0.59	ND–0.19	0.15– 2.80	ND	ND–0.31	ND–0.19	ND–0.22	ND–0.13	ND–0.60	ND–0.25
Hemp Island	1.05	0.41	4.10	0.13	0.10	0.83	0.48	0.44	—	0.65
	0.16	—	0.94	—	—	—	—	—	—	—
	0.70	0.30	1.50	—	—	0.45	0.33	0.18	—	0.30
	0.28	—	0.61	—	—	—	—	—	—	0.10
	—	—	0.25	—	—	—	—	—	—	—
	0.52	—	1.10	—	—	—	—	—	—	—
	0.58	—	0.60	—	—	—	—	—	—	0.22
	0.16	—	0.80	—	—	—	—	—	—	—
	0.73	—	3.30	—	—	0.15	0.18	—	—	0.26
	0.60	0.13	1.40	—	—	0.13	0.15	—	—	0.19
	0.63	0.11	1.80	—	—	0.13	0.14	—	0.23	0.15
	0.29	—	1.70	—	—	—	—	—	—	0.12
	0.23	—	0.50	—	—	—	—	—	—	—
	0.31	0.13	1.30	—	—	—	—	—	—	0.11
	0.40	—	1.30	—	—	—	0.10	—	—	0.10
GM	0.42		1.24							0.12
CL	0.29–0.58		0.82– 1.77							0.08–0.18
Range	ND–1.05	ND–0.41	0.50–4.10	ND–0.13	ND–0.10	ND–0.83	ND–0.48	ND–0.44	ND–0.23	ND–0.65

(Continued next page)

TABLE 8 (Cont'd.). *Organochlorine residues in brown pelican eggs, Florida, 1974*

Colony	Residues, µg/g fresh wet weight									
	DDE	TDE	PCBs	Heptachlor Epoxide	Mirex	*cis*-Chlordane	*trans*-Nonachlor	*cis*-Nonachlor	Toxaphene	Dieldrin
FLORIDA BAY										
Marquesas Key	0.13	—	—	—	—	—	—	—	—	—
	0.64	—	—	—	—	—	—	—	0.12	0.14
	0.23	—	0.41	—	—	—	—	—	—	—
	0.11	—	—	—	—	—	—	—	—	—
	0.42	—	—	—	—	—	—	—	—	—
	0.44	—	1.29	—	—	—	—	—	—	0.10
	1.05	0.14	1.60	—	—	—	—	—	0.14	0.14
	0.25	—	0.83	—	—	—	—	—	—	—
	0.42	—	1.06	—	—	—	—	—	—	—
GM	0.39		0.47							
CL	0.19–0.61		0.08– 1.00							
Range	0.11–1.05	ND–0.14	ND– 1.60	ND	ND	ND	ND	ND	ND–0.14	ND–0.14
Fanny Key	0.37	0.10	2.41	—	—	—	—	—	—	0.12
	0.19	—	0.85	—	—	—	—	—	—	—
ATLANTIC COAST										
Fort Pierce	1.61	0.31	10.90	—	—	0.16	0.18	0.11	—	0.26
	0.91	0.12	4.66	—	—	—	—	—	—	0.19
	1.47	0.34	8.89	—	—	0.10	—	0.13	—	0.42
	1.16	0.31	6.63	—	—	0.14	—	0.11	—	0.40
	0.60	0.19	3.98	—	—	—	—	—	—	0.24
	1.15	0.22	7.79	—	—	0.21	—	0.12	—	0.28
	2.15	0.65	12.92	—	—	0.21	0.11	0.20	0.20	0.41
	1.19	0.38	10.47	0.12	—	0.22	0.14	0.16	—	0.40
GM	1.24	0.31	7.79			0.13		0.10		0.31
CL	0.89–1.66	0.19–0.44	5.49–10.91			0.05–0.21		0.04–0.16		0.24–0.40
Range	0.60–2.15	0.12–0.65	3.98–12.92	ND–0.12	ND	ND–0.22	ND–0.18	ND–0.20	ND–0.20	0.19–0.42
Cocoa Beach	0.67	0.14	2.98	—	—	—	—	—	—	0.20
	1.81	0.45	7.80	—	—	0.16	0.12	0.14	0.25	0.35
	1.39	0.29	6.10	—	—	0.16	—	0.18	0.18	0.44
	1.13	0.32	4.77	—	—	0.15	0.17	0.13	0.14	0.34
	0.72	0.13	2.40	—	—	—	—	—	—	0.14
	0.44	0.19	5.16	—	—	—	—	—	0.21	0.27
	0.74	0.18	5.43	—	—	0.16	0.13	0.15	—	0.25
	0.85	0.23	3.00	—	—	0.13	—	0.11	0.10	0.41
	1.73	0.40	5.58	—	—	0.30	0.15	0.23	0.21	0.70
	1.72	0.40	8.35	—	—	—	0.13	—	—	0.38
	1.20	0.27	4.76	—	—	0.15	0.15	0.16	0.22	0.41
	1.20	0.28	7.77	—	—	0.16	0.10	0.13	0.21	0.33
	3.46	0.78	9.22	—	—	0.24	0.18	0.20	0.46	0.78
	0.94	0.29	3.38	—	—	—	—	—	0.44	0.23
	0.49	0.17	2.83	—	—	0.12	—	0.10	—	0.18
GM	1.13	0.29	4.94			0.11	0.07	0.10	0.15	0.32
CL	0.82–1.51	0.21–0.38	3.89– 6.24			0.06–0.16	0.03–0.11	0.05–0.15	0.07–0.24	0.25–0.42
Range	0.44–1.81	0.13–0.78	2.40– 9.22	ND	ND	ND–0.30	ND–0.18	ND–0.23	ND–0.46	0.14–0.78
Pelican Island	0.99	0.25	2.48	—	—	—	—	—	0.22	0.15
	1.33	0.25	5.77	—	—	0.19	0.12	0.20	—	0.33
	1.25	0.28	4.18	—	—	0.15	—	0.13	0.14	0.23
	1.01	0.16	3.07	—	—	—	—	—	—	0.26
	0.72	0.21	4.67	—	—	0.13	0.11	—	—	0.23
	1.11	0.35	6.36	—	—	0.13	0.16	—	—	0.31
	1.40	0.46	7.25	—	—	0.16	0.16	0.13	0.27	0.46
	1.77	0.62	9.73	0.11	—	0.18	0.20	0.15	0.30	0.60
	1.03	0.49	9.06	—	—	0.14	0.13	0.13	0.12	0.42
	1.40	0.60	9.52	—	—	0.35	0.30	0.25	—	0.65
	1.40	0.35	9.24	—	—	0.19	0.17	0.12	—	0.45
	0.49	—	2.71	—	—	—	—	—	—	0.13
	1.72	0.50	9.26	—	—	0.15	0.17	0.14	0.11	0.48
	0.66	0.13	1.98	—	—	—	0.12	—	—	0.15
GM	1.13	0.32	5.47			0.12	0.11	0.09		0.31
CL	0.92–1.37	0.22–0.43	3.96– 7.45			0.07–0.18	0.06–0.17	0.04–0.14		0.23–0.42
Range	0.49–1.77	ND–0.62	1.98– 9.73	ND–0.11	ND	ND–0.35	ND–0.30	ND–0.25	ND–0.30	0.13–0.60
Port Orange	1.67	0.43	10.01	—	—	0.18	0.17	0.10	0.26	0.43
	0.91	0.14	4.97	—	—	0.10	0.10	—	—	0.46
	1.80	0.65	7.80	—	—	0.24	0.21	0.14	0.23	0.54
	2.11	0.59	11.27	—	—	0.18	0.22	0.13	0.33	0.47
	2.64	0.74	11.78	0.10	—	0.53	0.34	0.26	0.29	0.62
	1.55	0.38	8.10	—	—	0.17	0.16	0.11	0.24	0.38

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TABLE 8 (Cont'd.). *Organochlorine residues in brown pelican eggs, Florida, 1974*

Colony	Residues, μg/g fresh wet weight									
	DDE	TDE	PCBs	Heptachlor Epoxide	Mirex	*cis*-Chlordane	*trans*-Nonachlor	*cis*-Nonachlor	Toxaphene	Dieldrin
	1.02	0.12	5.45	—	—	—	—	—	—	0.28
	1.16	0.34	6.05	—	—	0.24	0.15	0.11	0.12	0.31
	1.04	0.38	4.90	—	—	—	—	—	0.13	0.30
	0.45	0.10	4.17	—	—	—	—	—	—	0.18
	1.51	0.45	8.42	—	—	0.47	0.14	0.11	0.23	0.42
	1.00	0.37	8.30	—	—	—	—	—	0.41	0.83
	1.94	0.46	7.43	—	—	0.31	0.33	0.33	1.53	0.46
	1.34	0.22	9.70	—	—	—	0.12	—	0.18	0.28
GM	1.32	0.33	7.39			0.14	0.12	0.09	0.19	0.40
CL	1.03–1.71	0.23–0.47	6.13– 8.91			0.08–0.23	0.08–0.19	0.06–0.13	0.11–0.32	0.32–0.50
Range	0.45–2.64	0.10–0.74	4.27–11.78	ND–0.10	ND	ND–0.53	ND–0.34	ND–0.33	ND–1.53	0.18–0.83

NOTE: ND or — = no residue detected.
GM = geometric mean.
CL = 95 percent confidence limits.

TABLE 9. *Trends for organochlorine residues in brown pelican eggs, Deveaux Bank and Marsh Island, South Carolina, 1969–75*

Year	Sample Size	Residues, μg/g fresh wet weight					
		DDE	TDE	DDT	Σ DDT	Dieldrin	PCBs
1969	15	5.45[1] A[2] (4.44–6.70)	1.65 A (1.30–2.10)	0.45 A (0.15–0.83)	7.81 A (6.48–9.40)	1.16 A (1.03–1.52)	6.11 AB (5.00–7.45)
1970	13	3.58 B (2.23–5.72)	0.79 B (0.53–1.20)	0.55 A (0.42–0.69)	5.27 B (3.49–7.77)	0.82 B (0.52–1.32)	5.25 AB (3.92–7.04)
1971	65	2.48 C (2.27–2.71)	0.48 C (0.43–0.53)	0.17 B (0.13–0.21)	3.20 D (2.94–3.48)	0.46 C (0.40–0.52)	6.49 A (5.44–7.73)
1972	72	3.03 B (2.70–3.40)	0.36 C (0.31–0.42)	0.18 B (0.15–0.21)	3.69 C (3.31–4.12)	0.45 C (0.39–0.52)	7.51 A (6.68–8.46)
1973	104	2.09 D (1.91–2.29)	0.19 D (0.17–0.22)	0.17 B (0.15–0.20)	2.56 E (2.35–2.78)	0.45 C (0.41–0.50)	4.75 B (4.26–5.31)
1974	115	2.22 CD (2.03–2.43)	0.49 C (0.44–0.54)	0.02 C (0.01–0.04)	2.72 E (2.49–2.96)	0.58 C (0.53–0.64)	7.63 A (6.80–8.55)
1975	102	1.40 E (1.27–1.54)	0.41 C (0.37–0.46)	0.004 C (0.002–0.007)	1.80 F (1.64–1.97)	0.40 C (0.36–0.43)	6.45 A (5.75–7.24)

[1]Geometric mean; 95 percent confidence limits are in parentheses.
[2]See Footnote 2, Table 3.

The factors underlying the large population increase were not evident. The excellent reproductive success in 1973 cannot account for the large population increase just 2 years later. It is possible that many South Carolina adults did not breed before 1975 because of insufficient food. Many adult brown pelicans in Mexico and California apparently do not breed when the food supply is poor (*2*). The breeding population in South Carolina showed only a slight increase in 1973 when pelicans had an excellent reproductive season and menhaden were apparently readily available. Thus it is doubtful that large numbers of adult pelicans in South Carolina failed to breed from 1969 to 1974. There is no evidence from banding studies that large numbers of pelicans migrated from natal areas in Florida to South Carolina to breed. Although the population increase was probably caused by a combination of factors, the most likely factor seems to be the decline in organochlorine residues that resulted in improved reproductive success and probable increased longevity after fledging.

DDE is the organochlorine exerting most influence on reproductive success. However, little is known about adult mortality from organochlorines except that several

TABLE 10. *Organochlorine residue trends in brown pelican eggs from four regions, 1969–70, 1974*

Pollutant	Region[1]	Mean residues, μg/g fresh wet weight	
		1969–70	1974
DDE	SC	4.65 A[2]	2.22 B
	AC	2.32 B	1.21 C
	FB	1.04 C	0.37 D
	GC	1.48 C	0.36 D
TDE	SC	1.29 A	0.49 C
	AC	0.91 B	0.32 D
	FB	0.18 E	0.03 E
	GC	0.55 C	0.07 E
DDT	SC	0.49 A	0.02 C
	AC	0.43 A	0.01 C
	FB	0.07 C	ND C
	GC	0.27 B	ND C
Σ DDT	SC	6.52 A	2.72 C
	AC	3.68 B	1.52 D
	FB	1.25 D	0.39 E
	GC	2.27 C	0.42 E
Dieldrin	SC	1.09 A	0.58 B
	AC	0.51 B	0.36 C
	FB	0.06 D	0.04 D
	GC	0.11 D	0.13 D
PCBs	SC	5.77 B	7.63 A
	AC	2.68 C	6.12 AB
	FB	0.75 D	0.62 D
	GC	0.70 D	1.18 D

[1]SC = South Carolina, AC = Florida Atlantic Coast, FB = Florida Bay, and GC = Florida Gulf Coast.
[2]See Footnote 2, Table 3.

TABLE 11. *Organochlorine residues in tissues of brown pelicans found dead, South Carolina, 1974–75*

Year	Sex	Age	Tissue	Residues, µg/g fresh wet weight										
				DDE	TDE	DDT	Dieldrin	Heptachlor Epoxide	*cis*-Chlordane	*trans*-Nonachlor	*cis*-Nonachlor	Toxaphene	Mirex	PCBs
1974	F	4 wk	Carcass	0.14	—	—	—	—	—	—	—	—	—	0.25
			Brain	—	—	—	—	—	—	—	—	—	—	0.25
	F	6 wk	Carcass	0.16	—	—	—	—	—	—	—	—	—	1.44
			Brain	0.52	—	—	0.14	—	—	—	—	—	—	2.46
	F	12 wk	Carcass	0.46	0.16	—	0.13	—	—	—	—	—	—	1.27
			Brain	—	—	—	—	—	—	—	—	—	—	0.74
	M	8 wk	Carcass	0.15	—	—	—	—	—	—	—	—	—	1.28
			Brain	0.20	—	—	—	—	—	—	—	—	—	1.58
1975	M	AD	Carcass	3.09	1.25	0.14	1.67	0.22	0.44	0.56	0.47	0.56	1.40	25.28
			Brain	3.43	0.55	—	0.99	0.10	0.26	0.20	0.22	0.48	0.64	14.22
	M	AD	Carcass	3.24	1.56	0.14	1.87	0.26	0.62	0.92	0.71	0.73	1.80	38.80
			Brain	1.31	0.54	—	0.91	—	—	0.19	0.23	0.54	0.87	12.83
	M	AD	Brain	1.46	0.61	—	0.99	0.10	0.27	0.31	0.27	0.47	0.65	2.92

NOTE: — = no residues detected.
AD = adult.

TABLE 12. *Organochlorine residues in Atlantic menhaden regurgitated by brown pelicans, South Carolina, 1974–75*

Year		Residues, µg/g fresh wet weight							
		DDE	TDE	Heptachlor Epoxide	*cis*-Chlordane	*cis*-Nonachlor	*trans*-Nonachlor	Toxaphene	PCBs
1974		0.01	—	—	—	—	—	—	0.23
		0.04	—	—	—	—	—	—	0.19
		0.01	—	—	—	—	—	—	0.02
		0.06	0.04	0.02	—	0.01	—	—	0.36
		—	0.01	—	—	—	—	—	0.22
	GM	0.016							0.147
	CL	0.004–0.060							0.036–0.608
1975		—	—	—	—	—	—	—	—
		0.03	0.04	0.03	0.02	0.02	—	0.06	0.03
		0.01	0.03	—	—	—	—	0.02	0.03
		0.02	0.06	—	0.02	—	—	0.02	0.09
		0.03	0.06	0.03	—	0.01	—	—	0.08
		0.01	0.01	—	—	—	—	—	0.02
		0.02	0.03	—	0.01	—	0.01	—	0.10
		0.01	—	—	—	—	—	—	0.10
		0.02	0.03	—	0.01	—	0.01	0.02	0.15
		0.01	0.01	—	—	—	—	0.01	0.11
	GM	0.014	0.020						0.050
	CL	0.009–0.022	0.010–0.039						0.024–0.107

NOTE: — = no residues detected.
GM = geometric mean.
CL = 95 percent confidence limit.

pelicans have died of endrin and dieldrin poisoning. An increase in adult survival would have a marked effect on the breeding population and on the recruitment standard necessary to maintain a stable population. There are no data to support the theory of increased adult longevity, but it may be investigated in the future by analyzing banding data.

The South Carolina brown pelican population formerly numbered about 6,000 breeding pairs (*3, 10*), and if the present rate of reproductive success continues, the population should reach 6,000 breeding pairs within the next 5 years. The pelican population in Florida has been essentially stable since aerial surveys of nesting colonies were initiated in 1968 (*18, 21*).

Acknowledgments

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Pesticide Contamination of Water Rats in the Murrumbidgee Irrigation Areas, New South Wales, Australia, 1970–72

Penny Olsen [1] and Harry Settle [2]

ABSTRACT

Organochlorine pesticides were found in all samples of livers, kidneys, mammary glands, and fetuses of eastern water rats (Hydromys chrysogaster) *collected in the Murrumbidgee irrigation areas of New South Wales in 1970 and 1972. DDE was the predominant residue. Livers contained 0.01–3.10 ppm ΣDDT air-dried weight; kidneys, < 0.01–1.12 ppm; mammary glands, 0.14–23.75 ppm; and fetal liver, 0.28–0.66 ppm. Variations in residue levels are discussed in relation to the possible effects of environmental and physiological factors.*

Introduction

Large amounts of water are used in the Murrumbidgee irrigation areas of New South Wales for flood irrigation of rice crops. Drainage water from these crops and from irrigated orchards, vineyards, and cereal and vegetable crops enters Mirrool Creek. A weir, Willow Dam, controls entry of the creek's water into a storage swamp or diverts it for further irrigation use.

Several pesticides are used on area farms, although DDT predominates. About 1–4.5 kg/ha. is used annually (*2*), largely to control the bloodworm (*Chironomus* sp.) which damages rice seedlings. Eastern water rats (*Hydromys chrysogaster*), common in the irrigation area, were collected monthly from Mirrool Creek and Willow Dam as part of a study of the biology of the species.

Little is known of pesticide contamination of Australian fauna (*2*). The present study is a preliminary examination of the degree of exposure of water rats to pesticides.

Materials and Methods

SAMPLE COLLECTION

Eastern water rats were live-trapped from Mirrool Creek at Willow Dam near Griffith, New South Wales, between January 1970 and January 1973. Livers, kidneys, mammary glands, and fetuses were removed from the freshly killed rats and preserved in 10 percent formalin. A small number of samples taken during 1970 and 1972 were analyzed for pesticides as follows: in 1970, January (7), April (3), October (3), November (4); in 1972, February (2), May (2), July (7), August (6). Sampling pattern is illustrated in Figure 1.

ANALYSIS

In the laboratory, samples were drained and air dried, cut into small pieces, mixed with sodium sulfate, and extracted with hexane in a Soxhlet thimble for 4 hours. Extraction for a longer period did not increase residue recovery. The hexane extracts were concentrated to about 10 ml and partitioned three times with 25 ml acetonitrile as a preliminary cleanup. The acetonitrile phase was passed into 300 ml 2 percent sodium sulfate and shaken with 100 ml hexane. The hexane layer was dried by passing it through anhydrous sodium sulfate and was concentrated to 5 ml. The concentrate was mixed with 20 g 2 percent deactivated Florisil, poured into a chromatographic column containing 20 g 2 percent deactivated Florisil, and eluted in three fractions (*5, 6*) as follows:

Fraction A, eluted with 200 ml 20 percent methylene chloride–hexane, was analyzed for lindane, HCB, aldrin, heptachlor, heptachlor epoxide, DDE, TDE, DDT, and polychlorinated biphenyls (PCBs).

Fraction B, eluted with 200 ml 20 percent methylene chloride–hexane, was analyzed for dieldrin, dursban, and trithion.

Fraction C, eluted with 200 ml acetone, was analyzed for malathion, ethion, delnav, and diazinon.

The eluates were concentrated to 1 ml. Fractions A and B were examined by injection into a Varian Model 2700 gas-liquid chromatograph fitted with a tritium electron-capture detector. Fraction C was injected into

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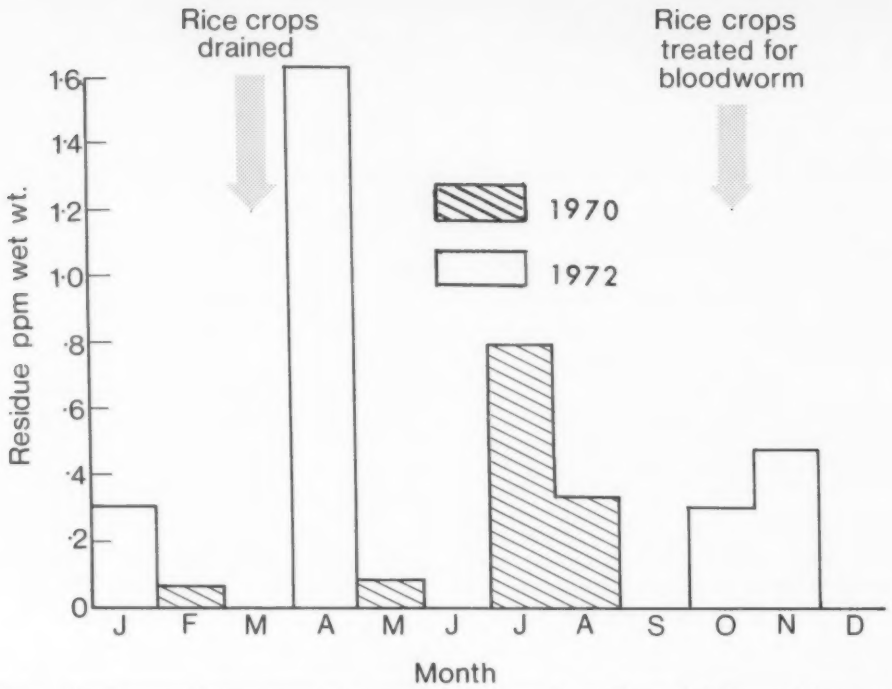

FIGURE 1. *Mean organochlorine content of eastern water rat livers by month sampled, Murrumbidgee irrigation area, New South Wales, Australia, 1970–72*
(ΣDDT represented at least 94 percent of residues in each month. Number of samples analyzed each month was 7, 2, 3, 2, 7, 6, 3, 4, respectively.)

a Tracor gas-liquid chromatograph fitted with a phosphorus-mode flame photometric detector (Table 1). Residues detected at 0.005 ppm and above were reported to the nearest 0.01 ppm.

CONFIRMATION OF RESIDUES AND RECOVERIES

All samples having organochlorine residues greater than 0.1 ppm were spotted on a thin-layer chromatographic plate for confirmation. Blank analyses were carried out at frequent intervals from the sodium sulfate/Soxhlet step. Replicate recoveries (Table 2) were carried out by adding known amounts of organochlorine and organophosphorus pesticides to sodium sulfate in the Soxhlet thimble and treating the recovery as in the sample procedure.

TABLE 1. *Parameters for gas-liquid chromatographic analyses for pesticides in eastern water rats, 1970–72*

	VARIAN 2700	TRACOR 550
Detector	tritium	FPD (P mode)
Columns	glass ⅛-inch I.D., 6 foot effective length	
Column packing	a mixture of 0.2% DC-200 and 0.8% QF-1 on Varaport 30	3% OV-1 on Gas-Chrom Q
Temperatures, °C		
column	200	220
inlet	220	230
detector	220	170
Carrier gas flow (ml/minute)		
nitrogen	30	60
hydrogen		50
air		100

Because a one-step cleanup was not sufficient, the acetonitrile–hexane partition method was used (*6*). This results in low HCB recoveries; consequently HCB results were corrected for recovery as follows:

$$\text{HCB (reported)} = \text{HCB found in determination} \times (100/33)$$

Results and Discussion

Pesticide residues detected in the water rats are listed in Table 3. All samples contained organochlorines and an unidentified organophosphorus compound. There were no significant differences in residue levels between males and females. Mammary glands, because of their fatty composition, contained the highest levels, and residues tended to increase as parturition approached. Mammary TDE positively correlated with fetal weight

TABLE 2. *Results of replicate recoveries of organochlorines and organophosphates in eastern water rats, 1970–72*

Pesticide	Amount added, µg	No. of replicates	Mean % recovery ± std dev
HCB	0.25	6	33.0 ± 4.49
DDE	0.25	4	76.5 ± 6.70
TDE	0.25	6	89.0 ± 8.61
DDT	0.25	only 2 recoveries measured	(71% and 92%)
Dieldrin	0.25	7	83.0 ± 6.36
Malathion	1	4	98.8 ± 8.93
Diazinon	1	5	75.4 ± 13.31
Delnav	1	4	85.8 ± 4.91
Dursban	1	6	86.7 ± 7.49
Ethion	1	5	84.6 ± 4.03
Trithio	1	5	86.2 ± 7.68

($P < 0.05$). Liver TDE was correlated with mammary TDE ($P < 0.001$). Fetal residues tended to reflect maternal liver residues and were positively correlated with fetal weight ($P < 0.01$).

No significant differences in residues were found between younger and older animals and breeding and nonbreeding animals (Table 4). However, younger animals tended to carry lower levels than older animals. The nonbreeding female group was the only one which showed a positive correlation between age and residue level ($P < 0.05$). Breeding females had the highest liver pesticide loads, and nonbreeding females, mature and immature, had the lowest. Kidney residues were lower in breeders than in nonbreeders.

Stomachs of pregnant females contained more food items, particularly insects, than did those of males or nonbreeding females (*8*). This suggests that breeders may have a greater opportunity for contamination through greater food consumption and may consume more dead and dying nontarget arthropods weakened by insecticides, as demonstrated by Stehn in small mammal scavengers (*7*). Lower liver residues in nonbreeding females and increasing residues in mammary glands as parturition approached suggested a lowering of body burdens through mobilization of fat during pregnancy and lactation; this phenomenon is thought to occur in harbor porpoises (*3*) and Arctic ringed seals (*1*).

Seasonal changes in residue levels may be related to irrigation and pesticide application practices in the area. Peak residues occurred in animals in April after water had been drained from the rice fields in March (Fig. 1). Because DDT has a low water solubility and deposits out of suspension to be adsorbed on organic matter, plants, and sediments (*4*), increased amounts may be available to water rat prey in the dry soil of drained rice fields and, particularly, through flushing of water with suspended clay, organic matter, and plant material into the creek.

Up to 8 ppm DDT has been found in sediments of drainage channels adjacent to the rice bays, indicating considerable movement of the pesticide from the site of application (K. H. Bowmer, Division of Irrigation Research, 1974, personal communication). Fish and aquatic insects may also be flushed from the bays or may be stranded in drained fields, becoming easy prey. A smaller peak in residue levels in November coincides with the treatment of rice for bloodworm.

Corresponding with the April peak residue levels, there was a seasonal decline in weight of the rats which may indicate a breakdown of body fats and consequent release of stored pesticides. Because trophic level is thought to be one factor in biomagnification of residues,

TABLE 3. *Pesticide residues in liver, kidney, mammary glands, and fetal liver samples from water rats, Murrumbidgee irrigation areas, New South Wales, Australia, 1970–72*

Tissue	No. Samples	Residues, ppm air-dried wt (± std dev.) (Range) DDE	TDE	DDT	Dieldrin	HCB	ΣDDT
Females							
Livers[1]	17	0.40 ± 0.14 (2.10–0.01)	0.09 ± 0.05 (0.85–ND)	0.01 (0.06–ND)	0.01 ± 0.01 (0.09–ND)	0.03 ± 0.02 (0.40–ND)	0.49 ± 0.19 (3.10–0.01)
Kidneys	12	0.17 ± 0.03 (0.46–ND)	0.03 ± 0.01 (0.15–ND)	ND	ND	0.01 ± 0.01 (0.11–ND)	0.20 ± 0.03 (0.57–0.06)
Mammary glands	6	5.07 ± 2.22 (12.20–0.13)	2.11 ± 1.68 (10.40–ND)	0.64 ± 0.37 (2.23–ND)	0.01 ± 0.01 (0.05–ND)	ND	7.82 ± 3.86 (23.75–0.14)
Fetal liver	2	0.30 (0.38–0.22)	0.13 (0.23–0.02)	0.05 (0.05–0.04)	0.04 (0.05–0.02)	ND	0.47 (0.66–0.28)
Males							
Livers	17	0.44 ± 0.10 (1.57–0.02)	0.05 ± 0.02 (0.22–ND)	ND (0.04–ND)	0.01 (0.04–ND)	ND (0.08–ND)	0.49 ± 0.11 (1.61–0.02)
Kidneys	13	0.31 ± 0.06 (0.89–ND)	0.02 ± 0.01 (0.20–ND)	ND	0.01 (0.04–ND)	0.01 (0.08–ND)	0.33 ± 0.07 (1.12–ND)

NOTE: PCBs not detected in any sample; ND = <0.01 ppm.
[1]One liver with 0.01 ppm malathion.

TABLE 4. *Differences in organochlorine residues in livers and kidneys of eastern water rats, Murrumbidgee irrigation areas, New South Wales, Australia, 1970–72*

	Mean total residues, ppm wet wt	
	Liver	Kidney
Females		
Est. age < 6 months	0.39 (5)	0.10 (2)
Est. age ≥ 6 months	0.64 (12)	0.26 (10)
Nonbreeding	0.40 (11)	0.24 (8)
Pregnant only	0.83 (4)	0.18 (3)
Pregnant and lactating	0.67 (2)	0.06 (1)
Males		
Est. age < 6 months	0.33 (5)	0.36 (4)
Est. age ≥ 6 months	0.56 (12)	0.33 (9)

NOTE: Age of all animals was estimated by use of dry eye lens weights. Tests were scrotal in males 6 months or older and nonscrotal in those younger than 6 months. Number of animals used in samples is in parentheses.

it is of interest that in the months of high residue levels, April–August, vertebrates were more important in the diet and insects were less important (*8*). Although stomach and rectal contents revealed food intake over a limited period, they may represent individual preference and reflect seasonal trends. Higher residues were found in those animals with fish, mammal, bird, and crustacean remains in their guts than in those with insects and spiders ($P < 0.01$). Mean liver residues and corresponding stomach contents were as follows: mammals ($n = 3$), 0.99 ppm; fish ($n = 3$), 1.29 ppm; birds ($n = 5$), 1.04 ppm; crustaceans ($n = 2$), 1.89 ppm; spiders ($n = 4$), 0.33 ppm; and insects ($n = 9$), 0.51 ppm.

There was no significant difference between residue levels in 1970 and 1972. HCB was found in 1970 samples only. Dieldrin, found in 4 of 17 liver samples (0.01–0.03 ppm) in 1970, occurred in 7 of 17 samples in 1972 (0.01–0.09 ppm). DDT and dieldrin sales were unchanged during the study. However, in 1972, the organophosphate abate was used in more rice-growing areas for bloodworm treatment, and HCB was no longer recommended for use as a fungicide.

Data from other studies on water rats are scarce. The Australian Academy of Science (*2*) reports in its appendices that residues of ΣDDT in a water rat in Victoria were: fat, 0.50; muscle, 0.23; kidney, 0.19 ppm wet weight. However, no biological information or locality is given.

Although DDT is no longer recommended for bloodworm control, the moderate degree of contamination found in water rats and the continuing use of potentially harmful pesticides in the area point to the need for a more detailed study on the fate and ecological effect of these substances, with particular emphasis on more sensitive species.

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Organochlorine Residues in Harp Seal (Phagophilus groenlandicus) *Tissues, Gulf of St. Lawrence, 1971, 1973*[1]

K. T. Rosewell, D. C. G. Muir, and B. E. Baker

ABSTRACT

Levels of p,p′-DDT, p,p′-TDE, p,p′-DDE, dieldrin, polychlorinated biphenyls (PCBs), and HCB were determined in certain tissues of 31 harp seals (Phagophilus groenlandicus) *taken from the Gulf of St. Lawrence during 1971 and 1973. The seals ranged in age from less than two weeks to 18 years. Mean concentrations of PCBs and ΣDDT in the various tissues were about the same. ΣDDT levels were 1.64–9.88 ppm in adult seal blubber and 1.08–3.73 ppm in seal pup blubber. Organochlorine levels in harp seal samples taken in 1973 were similar to those reported by other workers for samples collected in the Gulf of St. Lawrence during 1967–71.*

Introduction

Seals occupy a top position in long food chains, and because they carry large quantities of subcutaneous fat which can store organochlorines, they have been used as indicators of pollution in the marine environment (*1, 3, 5, 7, 8, 11, 13*). Organochlorine concentrations in seals collected in 1967 and 1968 in the Gulf of St. Lawrence indicated a degree of marine pollution similar to that in European coastal waters (*10*). In the present study, harp seals (*Phagophilus groenlandicus*) from the Gulf of St. Lawrence region were examined for organochlorines to determine whether 1967–68 marine pollution levels still existed and to measure organochlorine residue levels in various tissues of adult and young harp seals.

Materials and Methods

SAMPLE COLLECTION

Tissue samples were obtained from 11 harp seals (age 1–18 years) caught in the Gulf of St. Lawrence in 1971, and 20 harp seal pups caught in the same region in 1973. All samples were frozen immediately after collection and transported to the laboratory where they were stored at −20°C until analysis. Blubber, kidney, liver, muscle, spleen, brain, and gonad tissues were taken for analysis.

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ANALYTICAL METHODS

Tissue samples obtained in 1971 were analyzed as described by Porter et al. (*16*) for their fat content in order to estimate how much tissue would contain the 1–3 g of fat required for organochlorine analysis.

An appropriate weight of each sample was dried with sodium sulfate and then extracted with petroleum ether (*16*). The petroleum ether extracts were cleaned by acetonitrile–petroleum ether partitioning and Florisil column chromatography (*17*). The 6:94 (v/v) diethyl ether:petroleum ether eluate from the Florisil column was transferred to a 4:1 (by weight) silica–Celite column (*4*) in order to separate PCBs from ΣDDT. The 15 percent eluate from the Florisil column, which contained dieldrin residues, was subjected to further cleanup in which concentrated eluate was refluxed with 2:92 (v/v) methanolic KOH (*17*).

Tissue samples from harp seal pups caught in 1973 were analyzed for fat content by the method of Holdrinet (*12*). An appropriate weight of each sample was mixed with sodium sulfate and sand and then extracted with hexane on a Soxhlet extractor. The hexane extracts were cleaned on a deactivated (2 percent) Florisil column (*12, 15*), and then were passed through a charcoal column (*12*) in order to separate PCBs and HCB from ΣDDT.

Pesticides and PCBs were determined by (^{3}H) electron-capture gas chromatography under the following conditions:

Chromatograph:	Varian Model 600D
Columns:	(1) glass, 1.08 m × 3 mm OD, packed with a mixture of 6 percent QF-1 and 4 percent SE-30 on Chromosorb W-HP
	(2) glass, 1.68 m × 3 mm OD, packed with 1 percent OV-1 on Chromosorb W-HP
Temperatures, °C:	column (1) 195
	column (2) 185
Chromatograph:	Varian Model 1400
Columns:	glass, 1.83 m × 3 mm ID packed with:
	(1) a mixture of 6 percent QF-1 and 4 percent SE-30 on Chromosorb W-HP
	(2) 3 percent OV-225 on Chromosorb W-HP
Temperatures, °C:	column (1) 215
	column (2) 185

Known quantities of pesticides (*p,p′*-DDT, *p,p′*-TDE, *p,p′*-DDE, and dieldrin) and PCBs (Aroclors 1242 and

1260) were added to a sample of the sodium sulfate used to dehydrate the tissues. Extraction by the method of Porter et al. (*16*) produced recoveries of 69–102 percent for organochlorine pesticides and 69–84 percent for PCBs. The following recoveries were obtained using the method of Holdrinet (*12*): *p,p'*-DDT, *p,p'*-TDE, and *p,p'*-DDE, 85–112 percent; dieldrin, 81–89 percent; PCBs (Aroclor 1254), 84–85 percent; HCB, 78–89 percent.

Gas-liquid chromatography results were confirmed by use of two columns of different polarity, by thin layer chromatography, and by chemical derivatization. In all instances, the results were confirmed by at least two of the three procedures.

Results and Discussion

The fat content of seal tissues is shown in Table 1. Tables 2 and 3 show the results, not corrected for recovery, of analyses of the various tissues for organochlorines. ΣDDT and PCBs were detected in all samples. Dieldrin was detected in all but five tissue samples analyzed. Forty of 42 tissue samples from harp seal pups contained HCB. Blubber contained the highest levels of organochlorines. The mean PCB and ΣDDT concentrations in various tissues were about the same.

Mean HCB levels, determined only in seal pups, and mean dieldrin levels were similar in all tissues analyzed.

Brain tissue contained more extractable lipid (8.3 percent) than did liver (3.5–4.0 percent), kidney (4.2 percent), muscle (2.6 percent), and spleen (2.8 percent). Mean levels of ΣDDT and PCBs in the brain, however, were lower than in other tissues. The results suggest that a brain barrier to PCB- and DDT-type compounds may exist in the harp seal as reported by Frank et al. (*7*). This may result from a difference between the constitution of brain lipids and the lipids of depot fat. The authors suggest that a similar phenomenon may exist with dieldrin, but it was not observed in the present work.

TABLE 1. *Fat content of tissues of harp seals, Gulf of St. Lawrence—1971, 1973*

Tissue	No. Samples Analyzed	Average Fat Content, %
Blubber (adults)	5	82.5
(pups)	7	86.2
Liver (adults)	2	3.5
(pups)	3	4.0
Kidney (adults)	3	4.2
Muscle (adults)	2	2.6
Spleen (adults)	2	2.8
Brain (pups)	3	8.3
Gonad (male pups)	1	1.7
(female pups)	1	7.3

Since the types of residues in tissues of the harp seal pups were similar to those in the same tissues of older seals, it is probable that the residues in the adult seals are passed along to the fetus as well as to nursing seal pups. Holden concluded that organochlorine residues in nursing gray seal pups were derived solely from the parent seals, since the pups were still being fed by the adult females at the time of capture (*11*). This conclusion is supported by the fact that organochlorines have been found in the milk of fur seals (*2*) and harp seals (*6*).

Organochlorine levels in harp seal pups in the present study are similar to those reported previously in harp seals taken from the Gulf of St. Lawrence (*9, 10, 14*). In the present study, blubber, liver, and brain tissues of young harp seals contained PCB levels similar to and dieldrin levels higher than those found by Frank et al. (*7*). ΣDDT levels were slightly higher in the blubber and liver, but similar in brain tissue to those of pups studied by Frank et al. (*7*).

In the present study, the blubber of adult harp seals contained slightly lower levels of ΣDDT and PCBs than did those reported by Addison et al. (*1*) and Frank et al. (*7*). Muscle tissue of adult seals contained higher levels of PCBs but similar levels of ΣDDT and dieldrin. Liver tissue had lower levels of ΣDDT but higher concentrations of PCBs than did the corresponding tissue analyzed by the above authors (*1, 7*). Dieldrin concentrations in tissues analyzed for the present study were similar to those reported previously (*1, 7, 14*).

The ratio of ΣDDT to PCBs (Table 4) was close to 1.0 in all tissues except the liver, muscle, and spleen of the adult seals. This may reflect heavy use of DDT for spraying forests in areas drained by rivers flowing directly into the Gulf of St. Lawrence, as well as the high degree of urban industrial pollution which is the major source of PCBs in the environment.

Acknowledgments

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TABLE 2. *Organochlorine residues in tissues of adult harp seals, Gulf of St. Lawrence—March 1971*

Seal Number	Sex	Age, years	Tissue	Residues, ppm wet weight					
				p,p'-DDE	*p,p'*-TDE	*p,p'*-DDT	ΣDDT	Dieldrin	PCBs
1	M	11	blubber	0.680	0.359	1.096	2.135	0.320	2.05
			kidney	0.070	0.036	0.212	0.318	0.012	0.26
			liver	0.105	0.043	0.291	0.439	0.006	1.45
			muscle	0.138	0.039	0.102	0.279	0.005	0.47
			spleen	0.039	0.016	0.076	0.131	<0.002	0.16
2	F	1	blubber	0.918	0.433	8.530	9.881	0.244	0.49
			kidney	0.268	0.194	2.197	2.659	0.002	1.54
			liver	0.147	0.088	0.079	0.314	0.004	0.65
			muscle	0.048	0.017	0.063	0.128	0.002	1.10
			spleen	0.358	0.292	0.759	1.409	0.004	2.57
3	M	3	blubber	2.056	0.683	2.684	5.423	0.011	2.45
			kidney	0.145	0.060	0.206	0.411	0.005	0.86
			liver	0.060	0.075	0.147	0.282	0.007	0.37
			muscle	0.052	0.031	0.090	0.173	0.003	0.18
			spleen	0.108	0.059	0.086	0.253	0.004	0.55
4	M	5	blubber	0.726	0.631	2.550	3.907	0.024	13.30
			kidney	0.057	0.020	0.082	0.159	0.005	0.62
			liver	0.086	0.116	0.106	0.308	0.009	0.76
			muscle	0.089	0.018	0.097	0.204	0.002	0.34
5	M	6	blubber	1.187	0.459	1.280	2.926	0.096	1.96
			kidney	0.048	0.023	0.047	0.118	0.002	0.25
			liver	0.039	0.071	0.036	0.146	<0.002	0.11
			muscle	0.076	0.057	0.084	0.217	0.002	0.46
			spleen	0.056	0.038	0.156	0.250	<0.002	0.17
6	M	6	blubber	0.835	0.316	1.501	2.652	0.012	3.51
			kidney	0.097	0.041	0.039	0.177	0.004	0.45
			liver	0.170	0.086	0.055	0.311	<0.002	0.48
			muscle	0.094	0.040	0.106	0.240	0.005	0.32
			spleen	0.112	0.062	0.103	0.277	0.009	0.30
7	M	2–3	blubber	0.610	0.287	1.551	2.448	0.124	3.46
			kidney	0.034	0.016	0.042	0.092	<0.002	0.04
			liver	0.052	0.030	0.087	0.169	0.016	0.82
			spleen	0.051	0.021	0.059	0.131	0.002	0.07
8	M	1–2	blubber	1.063	0.732	3.391	5.186	0.010	1.53
			kidney	0.074	0.036	0.070	0.180	0.006	0.19
			liver	0.077	0.114	0.057	0.248	0.002	0.36
			muscle	0.091	0.087	0.130	0.308	0.003	0.77
			spleen	0.094	0.095	0.152	0.341	0.007	0.30
9	M	13	blubber	0.556	0.354	0.731	1.641	0.022	1.20
			kidney	0.071	0.022	0.128	0.221	0.005	0.18
			liver	0.217	0.149	0.455	0.821	0.018	0.36
			muscle	0.098	0.038	0.068	0.204	0.004	0.07
			spleen	0.075	0.023	0.091	0.189	0.010	0.33
10	M	13	blubber	1.849	0.770	2.300	4.919	0.022	2.77
			kidney	0.125	0.077	0.366	0.568	0.008	0.20
			liver	0.347	0.215	0.121	0.683	0.026	0.64
			muscle	0.060	0.033	0.112	0.205	0.008	0.06
			spleen	0.049	0.023	0.047	0.119	0.003	0.09
11	M	18	blubber	1.108	0.680	1.326	3.114	0.011	2.83
			kidney	0.061	0.047	0.064	0.172	0.005	0.31
			muscle	0.066	0.054	0.200	0.320	0.009	0.41
			spleen	0.043	0.161	0.090	0.294	0.016	0.07

NOTE: Detection limit = 0.002 ppm.

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TABLE 3. *Organochlorine residues in tissues of harp seal pups, Gulf of St. Lawrence—March 1973* [1]

Seal Number	Tissue	*p,p'*-DDT	*p,p'*-TDE	*p,p'*-DDE	ΣDDT	Dieldrin	HCB	PCBs
1	blubber	0.833	0.132	2.019	2.984	0.087	0.054	1.812
	liver	0.041	0.007	0.096	0.144	0.005	0.003	0.116
	brain	0.026	0.003	0.021	0.050	0.006	0.002	0.097
2	blubber	0.602	0.119	1.044	1.765	0.150	0.130	1.869
	liver	0.027	0.004	0.025	0.056	0.007	0.007	0.063
	brain	0.028	0.003	0.010	0.041	0.010	0.005	0.022
3	blubber	0.830	0.209	1.314	2.353	0.117	0.061	2.984
	liver	0.031	0.008	0.037	0.076	0.007	0.003	0.116
	brain	0.034	0.006	0.014	0.054	0.008	<0.002	0.037
4	blubber	0.460	0.079	0.690	1.229	0.092	0.109	1.392
	liver	0.038	0.006	0.036	0.080	0.006	0.007	0.112
	brain	0.022	0.003	0.011	0.036	0.006	0.004	0.029
5	blubber	0.599	0.100	0.787	1.486	0.075	0.106	1.601
	liver	0.032	0.004	0.019	0.055	0.004	0.005	0.043
	brain	0.007	0.002	0.007	0.016	0.004	0.003	0.019
6	blubber	0.811	0.096	1.206	2.113	0.103	0.114	1.476
	liver	0.023	0.004	0.024	0.051	0.004	0.005	0.039
	brain	0.015	0.002	0.010	0.027	0.006	0.003	0.017
7	blubber	0.750	0.129	1.713	2.592	0.082	0.062	2.908
	liver	0.023	0.005	0.040	0.068	0.003	0.003	0.071
	brain	0.023	0.004	0.017	0.044	0.005	0.002	0.039
8	blubber	0.670	0.144	1.294	2.108	0.096	0.034	2.623
	liver	0.031	0.008	0.060	0.099	0.009	0.004	0.145
	brain	0.019	0.003	0.016	0.038	0.009	0.002	0.033
9	blubber	0.729	0.115	1.294	2.138	0.096	0.055	2.664
	liver	0.021	0.006	0.041	0.068	0.004	0.003	0.099
	brain	0.034	0.005	0.014	0.053	0.007	<0.002	0.041
10	blubber	0.660	0.086	1.079	1.825	0.095	0.085	1.810
	liver	0.037	0.007	0.056	0.100	0.007	0.006	0.115
	brain	0.006	0.003	0.007	0.016	0.005	0.002	0.022
11	blubber	0.578	0.117	1.137	1.832	0.088	0.121	2.020
12	blubber	0.536	0.086	0.757	1.379	0.075	0.065	2.268
13	blubber	0.468	0.053	0.562	1.083	0.076	0.083	1.150
	gonad	0.023	0.003	0.012	0.038	0.002	0.002	0.045
14	blubber	0.634	0.132	1.327	2.093	0.093	0.119	2.225
	gonad	0.079	0.014	0.116	0.209	0.008	0.011	0.211
15	blubber	0.735	0.152	0.994	1.881	0.104	0.067	2.074
16	blubber	0.760	0.159	1.362	2.821	0.144	0.097	2.416
17	blubber	0.460	0.071	0.830	1.361	0.073	0.068	1.926
18	blubber	1.188	0.404	2.138	3.730	0.179	0.042	6.226
19	blubber	0.475	0.100	0.708	1.283	0.087	0.050	2.313
20	blubber	0.626	0.070	0.875	1.571	0.074	0.028	1.512

NOTE: Detection limit = 0.002 ppm.
[1] Age of pups <2 weeks.

TABLE 4. *Ratios of DDT to DDE and ΣDDT to PCBs in harp seal tissues, Gulf of St. Lawrence—1971–1973*

Tissue	DDT/DDE	ΣDDT/PCB
Blubber (adults)	2.32	1.24
(pups)	0.58	0.86
Liver (adults)	1.10	0.62
(pups)	0.70	0.92
Kidney (adults)	3.30	1.04
Muscle (adults)	1.30	0.54
Spleen (adults)	1.65	0.74
Brain (pups)	1.62	1.03

NOTE: Ratios calculated from mean concentrations of each residue.

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Nationwide Residues of Organochlorine Compounds in Starlings (Sturnus vulgaris), *1976*

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ABSTRACT

Organochlorine pesticide and PCB residues in starlings from 126 sites within the contiguous 48 states were monitored during fall 1976. The average nationwide level of DDE and PCBs has increased significantly since 1974, but the number of sites reporting PCB residues has decreased fivefold. Dieldrin residues have remained unchanged since 1974. Highest DDE levels occurred in samples from parts of Arizona, Arkansas, California, Louisiana, and New Mexico.

Introduction

The Fish and Wildlife Service, U.S. Department of the Interior, began nationwide monitoring of organochlorine residues in starlings *(Sturnus vulgaris)* in 1967–68 as part of the National Pesticides Monitoring Program. Residue data from the original collections were to serve as a baseline against which future residue levels might be compared. Initially, organochlorine compounds were to be monitored at 2-year intervals. However, in 1976, starling collections were scheduled at 3-year intervals to coincide with waterfowl wing collections which also are monitored nationwide for organochlorine residues. Starlings were selected because their range is the continental United States, they are considered expendable, and their omnivorous feeding habits should reflect residues from a wide range of food sources (*1*). The present report presents results of the 1976 starling collections including residue levels from each collection site, a comparison of nationwide averages of DDE, dieldrin, and polychlorinated biphenyls (PCBs) in the four collection periods since 1970, and the distribution of DDE, dieldrin, and PCBs by frequency of occurrence at collection sites.

Collection Methods

Sampling design and collection procedures have been reported previously (*1–3*). The sample area lies within the continental United States and consists of 40 blocks of 5° latitude and longitude. In the initial 1967–68 study, 139 collection sites were randomly selected within these blocks and were to be used for starling collections thereafter. During September–December 1976, samples were obtained from 126 of the sites. Table 1 lists collection sites for 1976 by state and county; Figure 1 shows their actual locations within sampling blocks.

Starling samples consist of pools of 10 birds taken by trapping or shooting, although some samples may be smaller; those samples with fewer than 10 birds are identified in Table 1. Each pool is wrapped in aluminum foil, placed in a polyethylene bag, frozen as soon as possible, and shipped to Raltech Scientific Services, Inc., Madison, Wisconsin, for chemical analysis. A total of 227 pools were analyzed for organochlorine residues.

Analytical Procedures

The feet, beaks, wing tips, and skins were removed from birds in each composite sample and the sample was weighed and ground in a food grinder. Twenty grams of the homogenate was ground with 150 g anhydrous sodium sulfate and allowed to air dry overnight in a hood. The dried sample was placed in a 43 mm × 123 mm Whatman extraction thimble and extracted for 8 hours on a Soxhlet apparatus with 150 ml ethyl ether and 150 ml petroleum ether. The resulting solution was concentrated to near dryness on a steam bath, and the remaining solvent was removed with nitrogen at room temperature. The residue was transferred to a 25-ml volumetric flask with 93:1 toluene–ethyl acetate solution and diluted to volume.

Five ml of the extract was placed on an Auto-Prep Model 1001 gel permeation chromatograph, standardized for chlorinated insecticides and PCBs, with the following operating conditions:

Packing:	80 g Bio-Beads (SX-3), 200–400 mesh
Column:	600 mm × 25 mm ID
Solvent:	3:1 toluene–ethyl acetate solution
Flow rate:	5.5 ml/minute
Dump time:	30 minutes
Collect time:	14 minutes
Wash time:	4 minutes

The resulting solution was concentrated on a flash evaporator to approximately 5 ml in the presence of 5 ml isooctane and diluted to 25 ml with petroleum ether. A 4-μl sample was injected into a gas chromatograph equipped with an electron-capture detector. If PCBs were not detected, the results were quantified.

[1] Fish and Wildlife Service, U.S. Department of the Interior, Patuxent Wildlife Research Center, Gulf Coast Field Station, P.O. Box 2506, Victoria, TX 77901.

TABLE 1. *Organochlorine residues in starlings, continental United States, 1976*

State	County[1]	Site	Residues, ppm wet weight						
			DDE	DDT	Dieldrin	PCBs[2]	Heptachlor Epoxide	HCB	Chlordane Isomers
Alabama	Marion	3-H-1	0.28	ND	0.14	ND	0.05	ND	0.04
	Calhoun	4-H-3	0.31	ND	0.01	0.85	0.04	ND	0.04
Arizona	Navajo	3-C-3	0.13	ND	ND	ND	ND	ND	ND
	Yavapai	3-C-4	0.27	ND	0.03	ND	0.01	ND	ND
	Maricopa	4-C-1	5.00	ND	0.01	ND	0.01	ND	ND
	Graham (3)	4-C-2	3.41	ND	0.01	ND	ND	ND	ND
Arkansas	Yell	3-G-2	0.31	ND	ND	0.35	0.13	ND	0.06
	Lonoke	3-G-3	11.10	ND	0.09	0.15	0.17	ND	0.06
California	Colusa (9)	2-A-1	0.39	ND	0.02	ND	ND	ND	ND
	Shasta	2-A-2	0.16	ND	0.01	ND	ND	ND	ND
	Modoc	2-A-3	0.13	ND	0.01	ND	0.01	ND	ND
	Ventura	3-A-1	1.26	ND	0.04	ND	ND	ND	ND
	Monterey (9)	3-A-3	2.20	0.02	0.08	0.39	ND	ND	0.01
	Kern	3-B-4	3.14	ND	0.03	ND	ND	ND	ND
	Imperial	4-B-1	7.41	ND	0.02	ND	ND	ND	ND
	Los Angeles	4-B-2	1.37	ND	0.04	ND	ND	ND	ND
Colorado	Weld	2-D-4	1.36	ND	0.06	ND	0.01	ND	ND
	Montrose	3-D-1	0.26	ND	ND	ND	ND	ND	ND
	Crowley	3-D-2	0.15	ND	ND	ND	0.01	ND	ND
Connecticut	New London	2-K-2	0.54	ND	0.03	0.39	0.09	ND	0.17
Florida	Bay	4-H-1	0.23	0.04	0.09	0.28	0.04	ND	0.07
	Madison	4-I-3	0.90	ND	0.11	ND	0.07	ND	0.18
	Highlands	5-I-2	0.67	ND	0.01	ND	ND	ND	ND
Georgia	Upson	4-H-4	1.03	ND	0.16	0.44	0.30	ND	0.20
	Wayne	4-I-2	0.35	0.03	0.11	0.26	0.03	ND	0.13
Idaho	Nez Perce	1-B-1	0.16	ND	ND	ND	ND	0.01	0.01
	Owyhee	2-B-1	1.15	ND	0.03	ND	0.01	ND	ND
	Franklin	2-C-3	1.12	ND	0.05	ND	0.02	ND	ND
	Minidoka	2-C-4	2.06	ND	0.06	0.16	0.01	ND	ND
Illinois	Stephenson	2-G-1	0.49	ND	0.17	0.21	0.06	ND	0.05
	Adams	2-G-3	0.04	ND	0.22	ND	0.36	0.56	0.09
	Kane	2-H-2	0.65	ND	0.12	ND	0.04	ND	0.01
Indiana	Henry	2-H-3	0.02	ND	0.03	ND	0.03	0.03	0.01
Iowa	Fremont	2-F-3	0.05	ND	0.23	ND	0.12	ND	0.04
	Jasper (8)	2-G-2	0.08	ND	0.28	ND	0.17	0.01	0.06
	Marshall (9)	2-G-4	0.09	ND	0.07	ND	0.11	ND	0.02
Kansas	Rawlins	2-E-1	0.29	ND	0.02	0.15	ND	ND	ND
	Phillips (7)	2-E-2	0.05	ND	0.02	ND	ND	0.03	ND
	Kearny (9)	3-E-1	0.03	ND	0.02	ND	0.01	ND	0.03
	Nemaha	2-F-4	0.07	ND	0.16	ND	0.04	0.01	0.02
	Marion	3-F-2	0.04	ND	0.06	ND	0.03	0.06	0.02
Kentucky	Ohio	3-H-2	0.15	ND	0.04	ND	0.02	ND	0.03
	Hopkins (9)	3-H-4	1.04	ND	0.04	ND	0.02	ND	0.11
Louisiana	Jefferson	4-G-3	0.93	ND	0.04	0.42	0.08	0.02	0.10
	Rapides	4-G-4	10.70	ND	0.04	0.63	0.03	ND	0.01
Maine	Penobscot	1-K-2	0.13	0.06	0.01	0.24	0.01	ND	0.01
Michigan	Chippewa	1-H-1	0.03	ND	0.03	ND	ND	ND	ND
	Grand Traverse	1-H-2	0.47	ND	0.02	ND	ND	ND	ND
	Kent	2-H-1	0.17	ND	ND	0.11	ND	ND	ND
	Ingham	2-H-4	0.51	ND	0.02	ND	0.03	ND	0.01
Minnesota	Aitkin	1-G-1	0.05	ND	ND	ND	ND	ND	ND
	Renville	1-F-2	0.04	ND	0.03	ND	ND	ND	ND
Mississippi	Leake	4-G-1	0.42	ND	0.18	ND	0.26	ND	0.09
	Harrison	4-G-2	0.67	0.04	0.24	ND	0.11	ND	0.07
	Jackson	4-H-2	1.43	ND	0.07	ND	0.04	ND	0.03
Missouri	Butler (7)	3-G-1	0.12	ND	0.06	0.11	0.03	0.23	ND
	Bollinger	3-G-4	0.06	ND	0.02	ND	ND	ND	ND
Montana	Meagher (9)	1-C-1	0.03	ND	ND	0.14	ND	ND	ND
	Missoula	1-C-4	0.06	0.04	0.01	ND	0.02	0.02	ND
	Richland (6)	1-D-1	0.01	ND	ND	ND	ND	ND	ND
	Yellowstone	1-D-4	ND	ND	ND	ND	ND	ND	ND
Nebraska	Keith (7)	2-E-3	0.04	ND	0.02	ND	ND	ND	ND
	Brown	2-E-4	0.04	ND	0.02	ND	0.03	ND	ND
	Lancaster (6)	2-F-1	0.25	0.07	ND	0.14	0.05	0.01	0.04
	Clay	2-F-2	0.10	ND	0.07	ND	ND	ND	ND
Nevada	White Pine	2-B-3	0.07	0.04	ND	ND	ND	ND	ND
	Humboldt	2-B-4	0.53	ND	0.02	ND	0.02	ND	0.04
	Nye	3-B-2	0.17	ND	0.04	ND	ND	ND	ND
	Clark	3-B-3	0.20	0.04	0.06	0.32	0.10	ND	0.21
New Mexico	Bernalillo	3-D-3	0.60	ND	ND	ND	ND	ND	ND
	Santa Fe	3-D-4	2.20	ND	0.03	ND	ND	ND	ND
	Luna	4-D-1	0.63	ND	ND	ND	ND	ND	ND
	Otero	4-D-2	1.71	ND	0.02	ND	ND	ND	ND
	Chaves	4-D-3	12.40	ND	0.03	ND	0.03	ND	0.01
	Quay	3-E-2	0.15	ND	ND	ND	0.01	ND	ND

(Continued next page)

TABLE 1 (Cont'd.). *Organochlorine residues in starlings, continental United States, 1976*

State	County[1]	Site	Residues, ppm wet weight						
			DDE	DDT	Dieldrin	PCBs[2]	Heptachlor Epoxide	HCB	Chlordane Isomers
New York	Jefferson (5)	2-J-4	0.09	ND	ND	ND	0.03	ND	0.04
	Rensselaer (8)	2-K-1	0.99	0.03	0.02	ND	ND	ND	ND
North Carolina	Wilkes	3-I-1	0.08	ND	0.02	ND	ND	ND	ND
	Macon	3-I-3	0.51	ND	0.03	ND	ND	ND	ND
	Pender	3-J-1	1.21	ND	0.20	0.18	0.03	ND	0.11
North Dakota	McLean	1-E-3	0.03	ND	0.01	ND	ND	ND	ND
	Grand Forks	1-F-1	0.43	ND	ND	ND	ND	ND	ND
	Ransom	1-F-4	0.07	0.01	ND	0.16	ND	ND	ND
Ohio	Pickaway	2-I-1	0.05	ND	0.05	ND	0.04	0.73	0.05
	Wood	2-I-2	0.08	ND	0.15	ND	0.05	0.06	0.01
	Noble	2-I-3	0.08	0.04	0.01	ND	0.02	ND	0.03
Oklahoma	Beckham	3-E-4	0.14	ND	0.03	ND	0.02	ND	ND
	Canadian	3-F-1	0.06	ND	0.03	ND	0.05	0.03	ND
	Nowata (9)	3-F-3	1.52	ND	0.05	ND	0.02	ND	0.03
	Okmulgee	3-F-4	0.12	0.05	0.10	ND	0.01	ND	0.01
Oregon	Yamhill	1-A-3	0.67	ND	0.10	ND	0.15	0.10	0.01
	Lane	1-A-4	0.32	ND	0.05	ND	0.05	ND	ND
	Benton	1-A-5	0.27	ND	0.06	ND	0.02	ND	ND
	Klamath	2-A-4	0.20	ND	ND	ND	0.02	ND	ND
	Baker (9)	1-B-4	0.06	ND	ND	ND	ND	ND	ND
	Harney	2-B-2	0.15	ND	ND	ND	ND	ND	ND
Pennsylvania	Somerset (6)	2-J-2	0.46	ND	0.05	ND	0.06	ND	0.10
	Luzerne	2-J-3	0.59	0.04	0.06	0.48	0.06	ND	0.13
South Dakota	Potter	1-E-1	0.07	ND	0.02	ND	ND	ND	ND
	Butte	1-E-2	0.02	ND	ND	ND	ND	ND	ND
	Hughes	1-E-4	0.03	ND	0.02	ND	ND	ND	ND
	Brown	1-F-3	0.03	ND	0.02	ND	ND	ND	ND
Tennessee	Davidson	3-H-3	0.09	0.02	0.14	0.22	0.01	ND	0.05
Texas	Kinney	4-E-3	1.05	ND	0.05	ND	0.89	ND	0.05
	Cochran	4-E-4	0.11	ND	0.04	ND	0.04	0.01	ND
	Bexar (7)	4-F-1	0.15	ND	0.02	ND	0.04	0.02	0.04
	Clay	4-F-3	0.97	ND	0.04	ND	0.47	0.07	0.07
	San Patricio	5-F-1	0.23	ND	ND	ND	0.01	ND	ND
Utah	Weber	2-C-1	0.91	0.04	0.04	0.55	ND	ND	ND
	Duschesne	2-C-2	0.10	ND	ND	ND	0.02	ND	ND
	Millard	3-C-1	0.42	ND	0.01	ND	ND	ND	ND
	Grand	3-C-2	0.93	ND	ND	ND	0.08	ND	0.02
Vermont	Addison	1-K-1	0.14	ND	0.01	0.11	0.04	ND	0.10
Virginia	Amherst (8)	3-I-4	0.52	ND	0.02	ND	ND	0.02	ND
	Prince George (9)	3-J-2	0.38	ND	0.02	0.11	0.02	0.04	0.05
	Caroline	3-J-3	0.11	ND	0.06	ND	0.07	0.20	0.07
Washington	Yakima	1-A-2	0.26	ND	0.12	ND	0.03	0.54	ND
	Spokane (5)	1-B-2	0.38	ND	0.24	ND	ND	2.01	ND
	Whitman	1-B-3	0.27	ND	ND	ND	ND	0.51	ND
Wisconsin	Trempealeau (9)	1-G-3	1.16	ND	0.01	ND	0.01	ND	ND
	Marathon (9)	1-G-2	0.07	ND	ND	ND	ND	ND	ND
Wyoming	Big Horn	1-D-2	0.02	ND	0.01	ND	0.03	ND	ND
	Crook (9)	1-D-3	ND	ND	ND	ND	ND	ND	ND
	Goshen	2-D-1	0.21	ND	ND	ND	ND	ND	ND
	Washakie	2-D-2	0.07	ND	0.03	ND	0.02	ND	ND

NOTE: ND = not detected.
[1] Most samples consist of a pool of 10 birds. Numbers in parentheses indicate samples made up of fewer birds.
[2] PCBs were quantified on the basis of Aroclor 1254.

If PCBs were detected, the extracts were subjected to silicic acid separation. Ten ml of the extract from the gel permeation chromatograph was placed on a 15-g standardized Silicar CC-4 column. Typical elutions were as follows:

Fraction I: 60 ml petroleum ether, contains HCB and mirex
Fraction II: 350 ml petroleum ether, contains PCBs and some DDE
Fraction III: 150-ml mixture of 1 percent acetonitrile, 19 percent hexane, and 80 percent methylene chloride, contains the remaining organochlorine compounds

Fractions I and II were concentrated on a steam bath to 1–2 ml; Fraction III was concentrated on a flash evaporator to 1–2 ml. All were diluted to 10 ml with petroleum ether. Quantities of 4 μl per solution were injected into a gas chromatograph equipped with an electron-capture detector.

Determinations were made on a Hewlett-Packard Model 5710A gas chromatograph equipped with a linear Ni^{63} detector and automatic injector, attached to a Hewlett-Packard Model 3352C data acquisition system. Instrument parameters and operating conditions for determining chlorinated insecticides and PCBs follow:

Column:	glass, 1219 mm × 4 mm ID, packed with a mixture of 1.95 percent OV-17 and 1.5 percent QF-1 on 80–100-mesh Supelcoport
Temperatures, °C:	column 200 injector 250 detector 300
Carrier gas:	a mixture of 95 percent argon and 5 percent methane flowing at 33 ml/minute

Instrument parameters and operating conditions for determining chlordane isomers were:

Column:	glass, 1219 mm × 4 mm ID, packed with 3 percent OV-1 on 80–100-mesh Gas-Chrom Q
Temperatures, °C:	column 190 injector 250 detector 300
Carrier gas:	a mixture of 95 percent argon and 5 percent methane flowing at 32 ml/minute

Residues in 5 percent of the samples were confirmed by mass spectrometry. Recoveries were 74–120 percent; analytical results were not corrected.

All residues are expressed as ppm wet weight. They may be converted to dry or lipid weight by dividing a given wet-weight value by 0.30 or 0.05, the mean proportions of dry and lipid material in the samples. Quantification limit was 0.01 ppm for organochlorine compounds. Trace residues were not reported.

Results and Discussion

Residues of DDE, DDT, dieldrin, PCBs, heptachlor epoxide, hexachlorobenzene (HCB), and chlordane isomers in starlings collected in 1976 are shown in Table 1. Since collections were made in the fall, residues do not necessarily reflect year-round levels. Also, findings should not be interpreted strictly on a statewide basis because some starlings are migratory. However, samples from certain localities consistently contain fairly high residues, suggesting that samples reflect local environmental contamination. For example, when results from previous monitorings (*1–4*) are compared, samples from certain parts of Arizona, Arkansas, California, Louisiana, and New Mexico usually contain higher DDE levels than do those from other states.

A summary of DDE, dieldrin, and PCB residues in starlings from 1970 through 1976 is shown in Table 2. The average DDE level in 1976 was similar to the 1970 level, before the use of technical DDT had been suspended. In fact, DDE residues were significantly higher nationwide ($P<0.001$) in 1976 than in 1974 (Table 2). It is difficult to explain why DDE residues have increased sharply since 1974, when residues were at their lowest level in 7 years. Possibly, DDT or its related

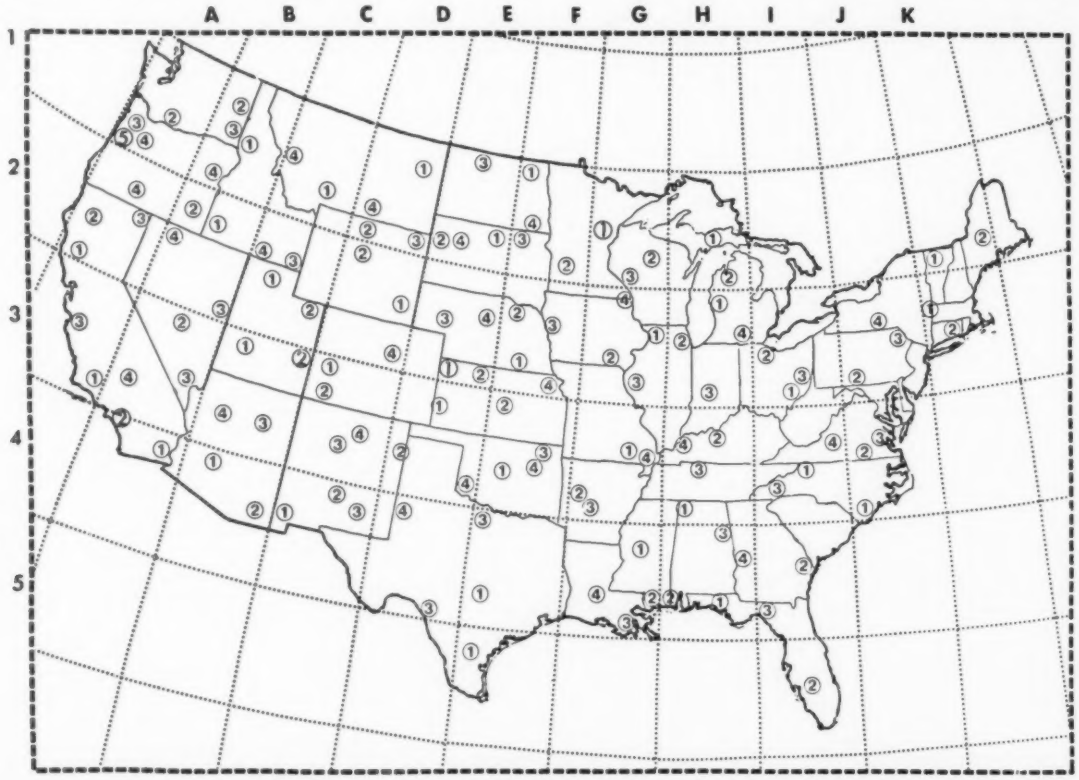

FIGURE 1. *Starling collection sites, continental United States, 1976*

TABLE 2. *Comparison of DDE, dieldrin, and PCB residues in starlings, continental United States, 1970–76*

Year	No. Pools	Residues, ppm wet weight								
		DDE			Dieldrin			PCBs		
		$\bar{x} \pm SE$[1]	Range	Geom. $\bar{x}$	$\bar{x} \pm SE$	Range	Geom. $\bar{x}$	$\bar{x} \pm SE$	Range	Geom. $\bar{x}$
1970	125	0.839 ± 0.138 (125)	0.037–48.2	0.355	0.117 ± 0.038 (125)	0.005–3.59	0.036	0.663 ± 0.196 (125)	0.09–24.3	0.358
1972	130	0.788 ± 0.124 (130)	0.047–14.8	0.387	0.098 ± 0.018 (130)	0.005–1.56	0.035	0.425 ± 0.153 (130)	0.04–19.9	0.215
1974	126	0.617 ± 0.118 (126)	0.007– 9.1	0.229	0.057 ± 0.011 (122)	0.005–1.01	0.019	0.112 ± 0.016 (126)	0.01– 1.9	0.068
1976	126	0.827 ± 0.174[2] (124)	0.010–12.4	0.254	0.059 ± 0.006 (96)	0.010–0.28	0.039	0.290 ± 0.036[2] (26)	0.11– 0.85	0.243

[1] Figure in parentheses represents number of pools having detectable residues.
[2] Residues in 1976 significantly higher than in 1974 ($P<0.001$, Students *t-test*, log-transformed data).

compounds may have been used, especially in certain geographical regions of the country.

Dieldrin residues declined steadily between 1970 and 1974, but the average dieldrin level in 1976 was almost identical to the 1974 average (Table 2), indicating no further decline of dieldrin during the 2-year period.

PCBs have increased significantly nationwide ($P<0.001$) since 1974, although 1976 residues remained below those reported for 1970 and 1972 (Table 2). Only 26 samples contained PCBs in 1976 compared to 126 in 1974; although the average PCB level was higher in 1976 than in 1974, the number of sites reporting PCB residues decreased fivefold in 1976.

The distribution of DDE, dieldrin, and PCBs by frequency of occurrence at collection sites for 1976 is shown in Table 3. In general, residues were low; most values were between 0 and 1.0 ppm for the three compounds. Dieldrin and PCBs were not detected in starlings at levels greater than 1.0 ppm.

In addition to organochlorine compounds in Table 1, certain other chemicals were detected in starlings less frequently. TDE occurred in six samples, ranging from 0.01 to 0.10 ppm; mirex was found in 13 samples, mostly from southeastern states, ranging from 0.01 to 1.24 ppm; lindane was detected in six samples, ranging from 0.01 to 0.15 ppm; and endrin occurred in only three samples, ranging from 0.02 to 0.18 ppm.

TABLE 3. *Distribution of residues in starlings by frequency of occurrence, continental United States, 1976*

Range, ppm	Number of Sites with Residues		
	DDE	Dieldrin	PCBs
ND– 0.01	3	43	99
>0.01– 0.10	36	65	0
>0.10– 1.0	63	17	26
>1.0 –13.0	23	0	0

NOTE: ND = not detected.

Conclusions

Nationwide, residues of DDE in starlings have increased significantly since 1974 to approximately the level reported in 1970 samples. Average PCB levels also increased, but the actual number of samples containing PCB residues declined. Dieldrin levels have remained unchanged since 1974.

These data indicate that starlings can serve as indicators of environmental contamination and thus provide information on residue trends over time. Geographical differences in residue levels also were detected.

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SOILS

Pesticide Application and Cropping Data from 37 States, 1972— National Soils Monitoring Program

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ABSTRACT

This report summarizes pesticide application and cropping data collected in 1972 from 1,402 agricultural sampling sites in 37 states as part of the National Soils Monitoring Program. Pesticide application data are summarized by all sites, state, and crop. Tables generally give the number of sites reporting, number of times a compound was applied, percent occurrence, and arithmetic mean application rate.

Pesticides applied most frequently were atrazine, 2,4-D, captan, and trifluralin. Among selected major crops, pesticides were most frequently applied to sites growing field corn and cotton, least frequently to sites growing alfalfa/bur clover and mixed hay.

Introduction

The increasing use of chemical pesticides in agriculture in the past 30 years has helped fewer farmers feed more people than at any other time in history. Today, the American farmer not only feeds and clothes this Nation's population, but also contributes significantly to the rest of the world. Yet the sensible use of toxic compounds also carries the responsibility to minimize their effects on nontarget components of the environment.

In 1963, the President's Science Advisory Committee recommended that appropriate federal agencies "develop a continuing network to monitor residue levels in air, water, soil, man, wildlife and fish" (*1*). As a result of the recommendation, the National Pesticide Monitoring Program (NPMP) was established to determine levels and trends of pesticides and their degradation products in various components of the environment (*2*). The federal responsibility for monitoring pesticides was officially codified in Section 20 of the amended Federal Insecticide, Fungicide and Rodenticide Act of 1972 (PL 92-516).

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The National Soils Monitoring Program (NSMP) is an integral part of the NPMP and monitors residues in agricultural soils and raw agricultural crops. It was established in 1968 by the U.S. Department of Agriculture and is administered by the U.S. Environmental Protection Agency. The present report summarizes pesticide application and cropping data collected during 1972 (FY–73) from 1,402 sampling sites in 37 states. Data for composite soil and crop samples, collected from the sites for pesticide residue analysis, are presented in a separate report (*3*).

Sampling

The site selection criteria and statistical design of the NSMP have been described (*4*). In 1972, 1,533 sites in 37 states were scheduled for sampling (Fig. 1). At each 4-hectare (10-acre) site, the landowner or operator was interviewed concerning crops grown and the kinds and amounts of pesticides applied during the 1972 growing season.

Results and Discussion

COMPOUNDS APPLIED TO CROPLAND

Cropping and pesticide use data were received from 1,402 of the scheduled 1,533 sites or 91 percent. Of these, 742 or 53 percent of the sites had one or more pesticides applied during the 1972 growing season. Tables summarizing the application data show the number of sites reporting a pesticide application, the percent of sites reporting the pesticide application, and the average rate of application, expressed in pounds per acre and kilograms per hectare.

Table 1 lists the frequency of pesticide use on sample sites in various states and state groups. Because some small eastern states had very few sites, those with similar geographic location and/or agricultural characteristics were combined to obtain more representative data. State groups used were Mid-Atlantic: Delaware, Maryland,

FIGURE 1. *States scheduled for sampling, 1972—National Soils Monitoring Program*

TABLE 1. *Pesticide application data from 1,402 reporting sites in 37 states, 1972—National Soils Monitoring Program*

State	No. of Sites Reporting	Pesticides Used		No Pesticides Used	
		No.	%	No.	%
Alabama	20	9	45	11	55
Arkansas	47	29	62	18	38
California	52	22	42	30	58
Florida	15	7	47	8	53
Georgia	27	13	48	14	52
Idaho	30	15	50	15	50
Illinois	139	94	68	45	32
Indiana	74	45	61	29	39
Iowa	149	106	71	43	29
Kentucky	16	7	44	9	56
Louisiana	27	18	67	9	33
Michigan	50	26	52	24	48
Mid-Atlantic[1]	18	10	56	8	44
Mississippi	27	24	89	3	11
Missouri	81	39	48	42	52
Nebraska	97	40	41	57	59
New England[1]	11	1	9	10	91
New York	31	13	42	18	58
North Carolina	31	17	55	14	45
Ohio	67	31	46	36	54
Oklahoma	43	27	63	16	37
Oregon	37	15	41	22	59
Pennsylvania	34	14	41	20	59
South Carolina	16	10	63	6	37
South Dakota	106	45	42	61	58
Tennessee	22	10	45	12	55
Virginia/West Virginia[1]	24	4	17	20	83
Washington	45	26	58	19	42
Wisconsin	66	25	38	41	62
TOTAL	1,402	742	53	660	47

[1] Because some small eastern states had very few sites, those with similar geographic location and/or agricultural characteristics were combined to obtain more representative data. State groups used were Mid-Atlantic: Delaware, Maryland, and New Jersey; New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont; and Virginia and West Virginia.

and New Jersey; New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont; and Virginia and West Virginia. Among individual states and state groups, frequency of pesticide use ranged from 9 percent in the New England states to 89 percent in Mississippi.

ALL SITES

The 121 compounds applied to all sites included 54 herbicides, 38 insecticides, 20 fungicides, 4 acaricides, 2 defoliants, 2 soil fumigants, and 1 growth retardant (Table 2). The most commonly applied compounds were atrazine, 2,4-D, captan, and trifluralin, which were used on 14, 10, 8, and 7 percent of the sites, respectively.

BY STATE

Table 3 presents the application data by state or state group. Because of the number of states sampled, it is not feasible to discuss in detail the pesticide data from each state. However, pesticide application data from each state tended to reflect both the crops grown and the intensity of agricultural land use in the state. For example, Iowa, predominantly a corn- and soybean-producing state, recorded the use of 17 compounds on 149 sites. California, a fruit and vegetable producer, recorded 29 compounds used on 52 sites.

In Figure 2, the frequency of reported pesticide applications in each state was arbitrarily classified as follows: low, less than 25 percent of the sites reported pesticide application; medium, 25–59 percent reported applica-

TABLE 2. *Summary of compounds applied to 1,402 cropland sites in 37 states, 1972—National Soils Monitoring Program*

Compound	Trade Name if Noted	Sites Reporting Application		Average Total Application	
		No.	%	Lb/Acre	Kg/Ha
Alachlor	Lasso	86	6.1	1.38	1.55
Aldicarb	Temik	2	0.1	0.40	0.45
Aldrin		33	2.4	1.57	1.76
Amitrole		1	0.1	0.15	0.17
Ancrack		4	0.3	1.08	1.20
Atrazine	AAtrex	200	14.3	1.56	1.75
Azinphosmethyl	Guthion	4	0.3	1.23	1.37
Benefin	Balan	6	0.4	0.83	0.93
Benomyl	Benlate	3	0.1	2.58	2.90
Benzene hexachloride		2	0.1	1.25	1.40
Bromacil	Hyvar	2	0.1	0.42	0.47
Bromoxynil		1	0.1	1.25	1.40
Butylate	Sutan	17	1.2	1.68	1.89
Bux		25	1.8	0.88	0.98
Captafol	Difolatan	3	0.1	3.83	4.29
Captan		106	7.6	0.19	0.22
Carbaryl	Sevin	23	1.6	2.49	2.79
Carbofuran	Furadan	17	1.2	1.07	1.19
Carbophenothion	Trithion	3	0.2	0.78	0.87
Chloramben	Amiben	51	3.6	1.38	1.55
Chlorobenzilate	Acaraben	4	0.3	3.45	3.87
Chlordane		5	0.4	3.18	3.57
Chloroneb	Demosan	8	0.6	0.02	0.02
Chloropropham	Chloro-IPC	1	0.1	0.59	0.66
Chloropropylate	Acarolate	1	0.1	3.50	3.92
Chloroxuron	Tenoran	1	0.1	2.00	2.24
Copper carbonate (basic)		1	0.1	3.50	3.92
Cyanazine	Bladex	2	0.1	2.15	2.41
Cycloate	Ro-Neet	3	0.2	1.95	2.19
2,4-D		136	9.7	0.69	0.77
Dalapon	Dowpon	2	0.1	7.80	8.74
2,4-DB	Butyrac	7	0.5	0.91	1.02
DDT		21	1.5	5.83	6.53
DEF		6	0.4	0.99	1.11
Diazinon		8	0.6	0.52	0.59
Dibromochloropropane	Nemagon	1	0.1	0.50	0.56
Dicamba	Banvel D	12	0.9	0.34	0.38
Dichlone	Phygon	1	0.1	0.50	0.56
Dichloropropene	Telone	1	0.1	60.00	67.25
Dichlorprop	2,4-DP	1	0.1	2.00	2.24
Dicofol	Kelthane	2	0.1	0.75	0.84
Dicrotophos	Bidrin	2	0.1	0.08	0.09
Dimethoate	Cygon	6	0.4	0.58	0.65
DNBP	Premerge	16	1.1	1.24	1.39
Dinitrocresol		2	0.1	1.63	1.82
Diphenamid	Enide	1	0.1	1.00	1.12
Disulfoton	Di-Syston	13	0.9	0.38	0.43
Diuron	Karmex	11	0.8	0.71	0.80
Dodine	Cyprex	1	0.1	0.98	1.09
DSMA		8	0.6	2.51	2.81
Dyfonate		3	0.2	0.97	1.08
EMTS	Ceresan M	9	0.6	0.01	0.01
EPN		1	0.1	3.00	3.36
EPTC	Eptam	10	0.7	2.19	2.45
Ethion		3	0.2	3.35	3.75
Ethoprop	Mocap	1	0.1	1.00	1.12
Ethylmercury chloride	Ceresan Red	5	0.4	0.01	0.01
Fenac		1	0.1	1.25	1.40
Fenaminosulf	Dexon	1	0.1	0.01	0.01
Fensulfothion	Dasanit	4	0.3	2.79	3.13
Fentin hydroxide		2	0.1	8.75	9.81
Fluometuron	Cotoran	23	1.6	0.93	1.04
Folex		5	0.4	1.10	1.23
Heptachlor		5	0.4	1.26	1.41
Hexachlorobenzene	No-Bunt	11	0.8	0.04	0.04
Lead arsenate		1	0.1	4.00	4.48
Lindane		1	0.1	0.01	0.01
Linuron	Lorox	39	2.8	1.11	1.24
Malathion		83	5.9	0.04	0.04
Maleic hydrazide	MH	5	0.4	2.25	2.52
Maneb		3	0.2	0.70	0.78
MCPA	MCP	5	0.4	1.40	1.56
MCPB		5	0.4	0.85	0.95
Mercury		10	0.7	0.04	0.04
Methomyl	Lannate	1	0.1	0.34	0.38
Methoxychlor		11	0.7	0.19	0.21
Methylmercury acetate	Ceresan L	7	0.5	0.01	0.01
Methylmercury dicyandiamide	Panogen	3	0.2	0.01	0.01
Methyl trithion		1	0.1	0.25	0.28
Metribuzin	Sencor	1	0.1	0.50	0.56
Mevinphos	Phosdrin	1	0.1	0.25	0.28
Mirex		7	0.5	0.01	0.01
Molinate	Ordram	2	0.1	3.00	3.36
Monocrotophos	Azodrin	3	0.2	1.67	1.87
MSMA		21	1.5	2.36	2.65
Naled	Dibrom	1	0.1	1.00	1.12
Naptalam	Alanap	8	0.6	1.35	1.52
Nitralin	Planavin	9	0.6	1.16	1.30
Norea	Herban	3	0.2	1.57	1.76
Oil spray		2	0.1	55.00	61.64
Oxythioquinox	Morestan	1	0.1	0.08	0.09
Paraquat		7	0.5	0.43	0.48
Parathion, ethyl		17	1.1	2.29	2.57
Parathion, methyl		40	2.9	2.99	3.35
PCNB		7	0.5	0.02	0.02
Pebulate	Tillam	1	0.1	4.00	4.48
Pentachlorophenol	PCP	1	0.1	0.05	0.06
Phenylmercury acetate	PMA	4	0.3	0.02	0.02
Phorate	Thimet	26	1.9	1.79	2.01
Picloram	Borolin	1	0.1	0.75	0.84
Polyram		1	0.1	1.00	1.12
Prolate	Imidan	3	0.2	3.92	4.39
Prometryn	Caparol	4	0.3	0.87	0.98
Propachlor	Ramrod	40	2.9	1.93	2.16
Propanil	Stam	2	0.1	3.50	3.92
Propargite	Omite	2	0.1	1.59	1.78
Propham	IPC	2	0.1	1.75	1.96
Pyrazon	Pyramin	1	0.1	0.94	1.05
Simazine	Princep	5	0.4	2.82	3.16
Sodium chlorate		2	0.1	1.00	1.12
Sulfur		10	0.7	27.85	31.21
TCA		2	0.1	5.63	6.30
TCBC		1	0.1	8.00	8.97
TEPP		1	0.1	0.25	0.28
Terbacil	Sinbar	2	0.1	1.75	1.96
Thiram		14	0.9	0.03	0.03
Toxaphene		30	2.1	9.36	10.49
Trietazine		1	0.1	0.25	0.28
Trifluralin	Treflan	97	6.9	0.86	0.96
Vernolate	Vernam	6	0.4	1.20	1.35

TABLE 3. *Compounds applied to cropland sites by state, 1972—National Soils Monitoring Program*

Compound	Trade Name if Noted	Sites Reporting Application		Average Total Application	
		No.	%	Lb/Acre	Kg/Ha
ALABAMA, 20 SITES					
Atrazine	AAtrex	1	5.0	1.00	1.12
Benefin	Balan	3	15.0	0.75	0.84
Benomyl	Benlate	2	10.0	3.50	3.92
Captan		1	5.0	0.01	0.01
Disulfoton	Di-Syston	1	5.0	1.00	1.12
2,4-D		1	5.0	1.00	1.12
DNBP	Premerge	1	5.0	1.00	1.12
Linuron	Lorox	1	5.0	1.00	1.12
Naptalam	Alanap	1	5.0	2.00	2.24
Parathion, methyl		1	5.0	13.00	14.57
Toxaphene		2	10.0	8.50	9.53
Trifluralin	Treflan	2	10.0	2.00	2.24
Vernolate	Vernam	3	15.0	0.75	0.84
ARKANSAS, 47 SITES					
Alachlor	Lasso	2	4.3	3.25	3.64
Ancrack		1	2.1	0.50	0.56
Captan		3	6.4	0.01	0.01
Chloroxuron	Tenoran	1	2.1	2.00	2.24
DEF		1	2.1	0.50	0.56
DDT		5	10.6	3.90	4.37
Dicrotophos	Bidrin	2	4.3	0.08	0.09
Disulfoton	Di-Syston	1	2.1	0.01	0.01
Diuron	Karmex	2	4.3	1.25	1.40
DNBP	Premerge	4	8.5	0.94	1.05
DSMA		2	4.3	2.50	2.80
2,4-DB	Butyrac	4	8.5	0.88	0.98
EMTS	Ceresan M	2	4.3	0.01	0.01
EPN		1	2.1	3.00	3.36
Fluometuron	Cotoran	7	14.9	0.96	1.08
Folex		1	2.1	1.50	1.68
Linuron	Lorox	2	4.3	0.50	0.56
Mercury		7	14.9	0.05	0.05
Metribuzin	Sencor	1	2.1	0.50	0.56
MSMA		9	19.1	1.94	2.18
Naptalam	Alanap	3	6.4	0.83	0.93
Nitralin	Planavin	2	4.3	1.00	1.12
Paraquat		1	2.1	0.02	0.02
Parathion, ethyl		1	2.1	3.00	3.36
Parathion, methyl		9	19.1	2.69	3.02
Prometryn	Caparol	3	6.4	1.08	1.21
Thiram	Stimusoy	2	4.3	0.12	0.13
Toxaphene		8	17.0	4.84	5.43
Trifluralin	Treflan	12	25.5	0.77	0.86
CALIFORNIA, 52 SITES					
Alachlor	Lasso	1	1.9	0.50	0.56
Carbophenothion	Trithion	1	1.9	0.09	0.10
Chloroneb	Demosan	1	1.9	0.01	0.01
2,4-D		2	3.8	0.50	0.56
DNBP	Premerge	1	1.9	0.50	0.56
Dibromochloropropane	Nemagon	1	1.9	0.50	0.56
Dicofol	Kelthane	2	3.8	0.75	0.84
Disulfoton	Di-Syston	1	1.9	1.00	1.12
EPTC	Eptam	1	1.9	3.00	3.36
Fenaminosulf	Dexon	1	1.9	0.01	0.01
Malathion		1	1.9	1.00	1.12
MCPA	MCP	2	3.8	2.00	2.24
Methomyl	Lannate	1	1.9	0.34	0.38
Mevinphos	Phosdrin	1	1.9	0.25	0.28
Molinate	Ordram	2	3.8	3.00	3.36
Naled	Dibrom	1	1.9	1.00	1.12
Nitralin	Planavin	1	1.9	0.75	0.84
Paraquat		2	3.8	0.63	0.70
Parathion, ethyl		5	9.6	0.76	0.85
Parathion, methyl		2	3.8	0.36	0.40
Phorate	Thimet	2	3.8	1.00	1.12
Prolate	Imidan	1	1.9	0.75	0.84
Propanil	Stam	1	1.9	4.00	4.48
Propargite	Omite	1	1.9	1.68	1.88
Simazine	Princep	2	3.8	2.75	3.08
Sulfur		2	3.8	0.80	0.90
TEPP		1	1.9	0.25	0.28
Toxaphene		1	1.9	3.00	3.36
Trifluralin	Treflan	2	3.8	0.38	0.42
FLORIDA, 15 SITES					
Atrazine	AAtrex	1	6.7	2.00	2.24
Azinphosmethyl	Guthion	1	6.7	2.00	2.24
Carbophenothion	Trithion	1	6.7	1.50	1.68
Chlorobenzilate	Acaraben	4	26.7	3.45	3.87
Copper carbonate (basic)		1	6.7	3.50	3.92
Ethion	Ethodan	3	20.0	3.35	3.76
Fensulfothion	Dasanit	1	6.7	7.50	8.41
Oil spray		2	13.3	55.00	61.64
Sulfur		4	26.7	36.88	41.33
GEORGIA, 27 SITES					
Alachlor	Lasso	1	3.7	2.50	2.80
Atrazine	AAtrex	1	3.7	4.00	4.48
Benefin	Balan	1	3.7	1.13	1.27
Captan		1	3.7	0.01	0.01
Carbaryl	Sevin	5	18.5	2.40	2.69
DDT		1	3.7	4.50	5.04
Captafol	Difolatan	1	3.7	10.00	11.21
Disulfoton	Di-Syston	1	3.7	1.00	1.12
Fentin hydroxide	Du-Ter	2	7.4	8.75	9.81
Mirex		2	7.4	0.01	0.01
Maleic hydrazide	MH-30	1	3.7	6.00	6.72
Parathion, ethyl		2	7.4	2.75	3.08
Parathion, methyl		1	3.7	4.50	5.04
Sulfur		1	3.7	34.00	38.11
Toxaphene		2	7.4	5.25	5.88
Trifluralin	Treflan	1	3.7	1.00	1.12
IDAHO, 30 SITES					
Atrazine	AAtrex	2	6.7	0.75	0.84
Bromoxynil		1	3.3	1.25	1.40
2,4-D		7	23.3	1.21	1.36
DDT		1	3.3	1.00	1.12
EMTS	Ceresan M	2	6.7	0.01	0.01
EPTC	Eptam	1	3.3	0.25	0.28
MCPB		1	3.3	2.00	2.24
Sulfur		1	3.3	20.00	22.42
Trifluralin	Treflan	2	6.7	0.25	0.28
ILLINOIS, 139 SITES					
Alachlor	Lasso	10	7.2	1.24	1.38
Aldrin		6	4.3	1.10	1.23
Atrazine	AAtrex	23	16.5	1.33	1.49
Butylate	Sutan	9	6.5	0.94	1.06
Bux		2	1.4	1.30	1.46
Captan		45	32.4	0.01	0.01
Carbofuran	Furadan	3	2.2	0.75	0.84
Chloramben	Amiben	20	14.4	1.25	1.40
Chlordane		3	2.2	0.97	1.09
2,4-D		14	10.1	0.43	0.49
2,4-DB	Butyrac	1	0.7	0.50	0.56
Diazinon		2	1.4	2.01	2.25
Dicamba	Banvel-D	2	1.4	0.17	0.18
Dyfonate		1	0.7	0.50	0.56
EPTC	Eptam	1	0.7	0.42	0.47
Ethylmercury chloride	Ceresan Red	1	0.7	0.01	0.01
Heptachlor		2	1.4	1.65	1.85
Lindane		1	0.7	0.01	0.01
Linuron	Lorox	2	1.4	1.25	1.40
Malathion		44	31.6	0.01	0.01
Methoxychlor		5	3.6	0.01	0.01
Nitralin	Planavin	1	0.7	2.80	3.14
Phorate	Thimet	3	2.2	0.80	0.90
Propachlor	Ramrod	15	10.8	1.71	1.92
TCBC	Randox-T	1	0.7	8.00	8.97
Simazine	Princep	1	0.7	3.00	3.36
Trietazine	Gesafloc	1	0.7	0.25	0.28
Toxaphene		1	0.7	0.40	0.45
Trifluralin	Treflan	12	8.6	0.73	0.82
Vernolate	Vernam	1	0.7	0.45	0.50
INDIANA, 74 SITES					
Alachlor	Lasso	15	20.3	1.86	2.08
Aldrin		7	9.5	1.33	1.49

(*Continued next page*)

TABLE 3 (cont'd.). *Compounds applied to cropland sites by state, 1972—National Soils Monitoring Program*

Compound	Trade Name if Noted	Sites Reporting Application		Average Total Application	
		No.	%	Lb/Acre	Kg/Ha
Atrazine	AAtrex	20	27.0	1.83	2.05
Captan		6	8.1	0.01	0.01
Chloramben	Amiben	5	6.8	1.20	1.35
2,4-D		4	5.4	0.50	0.56
EPTC	Eptam	1	1.4	10.00	11.21
Linuron	Lorox	8	10.8	1.38	1.55
Malathion		6	8.1	0.01	0.01
Trifluralin	Treflan	3	4.1	1.00	1.12
IOWA, 149 SITES					
Alachlor	Lasso	10	6.7	0.86	0.97
Aldrin		8	5.4	1.20	1.35
Atrazine	AAtrex	38	25.5	1.38	1.55
Butylate	Sutan	6	4.0	2.75	3.08
Bux		13	8.7	0.90	1.01
Carbofuran	Furadan	4	2.7	0.98	1.09
Chloropropham	Chloro-IPC	1	0.7	0.59	0.66
Chloramben	Amiben	16	10.7	0.96	1.08
2,4-D		18	12.1	0.51	0.57
Diazinon		1	0.7	0.07	0.08
Dicamba	Banvel-D	6	4.0	0.25	0.28
Dyfonate		1	0.7	1.40	1.57
Ethoprop	Mocap	1	0.7	1.00	1.12
Heptachlor		1	0.7	1.00	1.12
Phorate	Thimet	8	5.4	1.06	1.19
Propachlor	Ramrod	14	9.4	1.74	1.95
Trifluralin	Treflan	22	14.8	0.80	0.89
KENTUCKY, 16 SITES					
Atrazine	AAtrex	5	31.3	1.00	1.12
Carbaryl	Sevin	2	12.5	1.50	1.68
2,4-D		1	6.3	1.00	1.12
Linuron	Lorox	1	6.3	0.75	0.84
Malathion		1	6.3	1.00	1.12
Methoxychlor		1	6.3	2.00	2.24
Trifluralin	Treflan	1	6.3	1.00	1.12
LOUISIANA, 27 SITES					
Alachlor	Lasso	1	3.7	1.00	1.12
Aldrin		1	3.7	0.01	0.01
Azinphosmethyl	Guthion	1	3.7	1.50	1.68
Chloramben	Amiben	1	3.7	1.50	1.68
2,4-D		3	11.1	1.12	1.25
2,4-DB	Butyrac	1	3.7	2.00	2.24
DCPA	Dacthal	1	3.7	0.75	0.84
DDT		5	18.5	11.30	12.67
DSMA		4	14.8	3.15	3.53
Dalapon	Dowpon	1	3.7	2.00	2.24
DEF		1	3.7	1.50	1.68
Dichlorprop	2,4-DP	1	3.7	2.00	2.24
Diphenamid	Enide	1	3.7	1.00	1.12
Diuron	Karmex	3	11.1	1.25	1.40
DNBP	Premerge	2	7.4	1.25	1.40
EMTS	Ceresan M	1	3.7	0.01	0.01
Fenac		1	3.7	1.25	1.40
Fluometuron	Cotoran	4	14.8	1.03	1.15
Folex		1	3.7	1.00	1.12
MSMA	Ansar	3	11.1	2.50	2.80
Norea	Herban	1	3.7	0.60	0.67
Parathion, methyl		8	29.6	3.66	4.10
Propanil	Stam	1	3.7	3.00	3.36
TCA		1	3.7	11.00	12.33
Terbacil	Sinbar	1	3.7	2.00	2.24
Thiram		1	3.7	0.01	0.01
Toxaphene		5	18.5	23.40	26.23
Trifluralin	Treflan	8	29.6	1.41	1.58
Vernolate	Vernam	1	3.7	2.50	2.80
MICHIGAN, 50 SITES					
Alachlor	Lasso	1	2.0	0.50	0.56
Aldrin		1	2.0	1.40	1.57
Atrazine	AAtrex	15	30.0	2.09	2.35
Captan		10	20.0	0.01	0.01
2,4-D		6	12.0	1.29	1.45
Dicamba	Banvel D	1	2.0	1.00	1.12
EPTC	Eptam	2	4.0	2.00	2.24
Linuron	Lorox	3	6.0	1.67	1.87
Malathion		10	20.0	0.01	0.01
Pyrazon	Pyramin	1	2.0	0.94	1.05
TCA		1	2.0	0.25	0.28
Trifluralin	Treflan	1	2.0	1.00	1.12
MID-ATLANTIC STATES,[1] 18 SITES					
Alachlor	Lasso	5	27.8	2.06	2.31
Atrazine	AAtrex	2	11.1	1.75	1.96
Azinphosmethyl	Guthion	1	5.6	0.90	1.01
Captan		4	22.2	0.01	0.01
Carbaryl	Sevin	2	11.1	1.92	2.15
Chlordane		1	5.6	5.00	5.60
2,4-D		1	5.6	0.50	0.56
Dichlone	Phygon	1	5.6	0.50	0.56
Dieldrin		2	11.1	0.26	0.29
Dimethoate	Cygon	1	5.6	0.66	0.74
Dinitrocresol		1	5.6	3.00	3.36
Linuron	Lorox	1	5.6	0.38	0.43
Maneb		1	5.6	1.44	1.61
Malathion		2	11.1	0.01	0.01
Parathion, ethyl		1	5.6	1.30	1.46
Prolate	Imidan	1	5.6	2.00	2.24
Sulfur		1	5.6	37.00	41.47
Thiram	Arasan	1	5.6	0.01	0.01
Trifluralin	Treflan	1	5.6	1.20	1.35
MISSISSIPPI, 27 SITES					
Alachlor	Lasso	1	3.7	2.00	2.24
Aldicarb	Temik	2	7.4	0.40	0.45
Ancrack		3	11.1	1.27	1.42
Azinophosmethyl	Guthion	1	3.7	0.50	0.56
Captan		1	3.7	0.03	0.03
Carbaryl	Sevin	1	3.7	1.00	1.12
Chloroneb	Demosan	7	25.9	0.03	0.03
2,4-DB	Butyrac	1	3.7	0.40	0.45
DDT		7	25.9	5.71	6.40
DEF		4	14.8	0.98	1.10
DSMA		2	7.4	1.24	1.39
DNBP	Premerge	7	25.9	1.70	1.91
Disulfoton	Di-Syston	5	18.5	0.01	0.01
Diuron	Karmex	2	7.4	0.30	0.34
Fluometuron	Cotoran	7	25.9	0.70	0.78
Folex		2	7.4	0.75	0.84
Linuron	Lorox	3	11.1	1.83	2.05
MSMA		7	25.9	2.75	3.08
Methylmercury acetate	Ceresan L	6	22.2	0.01	0.01
Mirex		4	14.8	0.01	0.01
Monocrotophos	Azodrin	3	11.1	1.67	1.87
Naptalam	Alanap	1	3.7	3.00	3.36
Nitralin	Planavin	3	11.1	1.33	1.49
Norea	Herban	1	3.7	1.60	1.79
Parathion, methyl		10	37.0	4.38	4.90
Sodium chlorate		2	7.4	1.00	1.12
Toxaphene		8	29.6	10.25	11.49
Trifluralin	Treflan	10	37.0	0.85	0.95
MISSOURI, 81 SITES					
Alachlor	Lasso	11	13.6	1.42	1.59
Atrazine	AAtrex	13	16.0	1.67	1.87
Aldrin		3	3.7	1.67	1.87
Chloramben	Amiben	2	2.5	3.01	3.37
2,4-D		3	3.7	0.42	0.47
Diuron	Karmex	1	1.2	0.25	0.28
Fluometuron	Cotoran	3	3.7	1.31	1.46
Linuron	Lorox	6	7.4	0.87	0.97
MSMA		1	1.2	3.40	3.81
Norea	Herban	1	1.2	2.50	2.80
Trifluralin	Treflan	11	13.6	0.73	0.82
NEBRASKA, 97 SITES					
Alachlor	Lasso	4	4.1	1.11	1.25
Atrazine	AAtrex	18	18.6	1.40	1.57
Bux		7	7.2	0.73	0.82
Carbofuran	Furadan	5	5.2	0.69	0.78

(Continued next page)

TABLE 3 (cont'd.). *Compounds applied to cropland sites by state, 1972—National Soils Monitoring Program*

Compound	Trade Name if Noted	Sites Reporting Application		Average Total Application	
		No.	%	Lb/Acre	Kg/Ha
Chloramben	Amiben	1	1.0	1.50	1.68
Cyanazine	Bladex	1	1.0	2.80	3.14
Cycloate	Ro-Neet	1	1.0	0.40	0.45
2,4-D		8	8.2	0.61	0.68
Diazinon		1	1.0	0.98	1.10
Dyfonate		1	1.0	1.00	1.12
EPTC	Eptam	1	1.0	1.75	1.96
Fensulfothion	Dasanit	1	1.0	0.90	1.01
Linuron	Lorox	2	2.1	0.94	1.05
Parathion, ethyl		2	2.1	0.65	0.73
Propachlor	Ramrod	5	5.2	2.13	2.39
Phorate	Thimet	3	3.1	0.88	0.99
Simazine	Princep	1	1.0	4.00	4.48
NEW ENGLAND,[1] 11 SITES					
Captan		1	9.1	19.20	21.52
Carbophenothion	Trithion	1	9.1	0.75	0.84
Chloropropylate	Acarolate	1	9.1	3.50	3.92
Dodine	Cyprex	1	9.1	0.98	1.10
Prolate		1	9.1	0.38	0.43
Propargite	Omite	1	9.1	9.00	10.09
NEW YORK, 31 SITES					
Alachlor	Lasso	2	7.1	0.88	0.98
Atrazine	AAtrex	10	32.3	2.03	2.27
Benomyl	Benlate	1	3.6	0.75	0.84
Bux		1	3.6	0.70	0.78
Captan		3	10.7	0.01	0.01
Carbaryl	Sevin	2	7.1	4.25	4.76
Carbofuran	Furadan	1	3.6	1.00	1.12
2,4-D		1	3.6	0.25	0.28
Diazinon		2	7.1	0.51	0.57
Dinitrocresol		1	3.6	0.25	0.28
DNBP	Premerge	1	3.6	0.21	0.24
EPTC	Eptam	1	3.6	0.25	0.28
Methoxychlor		4	12.9	0.01	0.01
Parathion, ethyl		1	3.6	0.33	0.37
Thiram		4	12.9	0.01	0.01
NORTH CAROLINA, 31 SITES					
Alachlor	Lasso	3	9.7	1.00	1.12
Atrazine	AAtrex	4	12.9	1.63	1.82
Carbaryl	Sevin	4	12.9	3.38	3.78
2,4-D		1	3.2	1.00	1.12
Dichloropropene	Telone	1	3.2	60.00	67.25
Fensulfothion	Dasanit	1	3.2	2.00	2.24
Lead arsenate		1	3.2	4.00	4.48
Linuron	Lorox	1	3.2	1.50	1.68
Maleic hydrazide		4	12.9	1.31	1.47
Maneb		1	3.2	0.41	0.46
Naptalam	Alanap	2	6.5	0.92	1.03
Nitralin	Planavin	1	3.2	0.50	0.56
Parathion, ethyl		2	6.5	10.50	11.77
Paraquat		2	6.5	0.38	0.42
Pebulate	Tillam	1	3.2	4.00	4.48
Phorate	Thimet	1	3.2	0.50	0.56
Pentachlorophenol	PCP	1	3.2	0.05	0.06
Toxaphene		1	3.2	10.00	11.21
Trifluralin	Treflan	1	3.2	0.80	0.90
OHIO, 67 SITES					
Alachlor	Lasso	4	6.0	1.14	1.27
Aldrin		6	9.0	3.33	3.74
Atrazine	AAtrex	13	19.4	1.89	2.12
Butylate	Sutan	1	1.5	2.00	2.24
Bux		1	1.5	0.80	0.90
Captan		1	1.5	0.01	0.01
Carbofuran	Furadan	1	1.5	1.00	1.12
Chloramben	Amiben	5	7.5	2.60	2.91
2,4-D		5	7.5	1.00	1.12
Dicamba	Banvel D	2	3.0	1.00	1.12
Linuron	Lorox	5	7.5	0.92	1.03
Methylmercury acetate	Ceresan L	1	1.5	0.01	0.01
Picloram	Borolin	1	1.5	0.75	0.84
Propachlor	Ramrod	1	1.5	8.00	8.97
OKLAHOMA, 43 SITES					
Alachlor	Lasso	2	4.7	2.00	2.24
Benefin	Balan	1	2.3	1.00	1.12
Captan		2	4.7	0.01	0.01
Carbaryl	Sevin	3	7.0	2.17	2.43
2,4-D		4	9.3	0.50	0.56
EMTS	Ceresan M	4	9.3	0.01	0.01
Ethylmercury chloride	Ceresan Red	1	2.3	0.01	0.01
MCPB		2	4.7	0.50	0.56
Parathion, methyl		8	18.6	0.50	0.56
PCNB	Terrachlor	6	14.0	0.02	0.02
Polyram		1	2.3	1.00	1.12
Thiram	Arasan	5	11.6	0.01	0.01
Trifluralin	Treflan	1	2.3	0.50	0.56
OREGON, 37 SITES					
Amitrole		1	2.7	0.15	0.17
Bromacil		1	2.7	0.09	0.10
Captan		2	5.4	0.01	0.01
Cycloate	Ro-Neet	1	2.7	5.20	5.83
2,4-D		11	29.7	0.72	0.81
Diazinon		1	2.7	0.10	0.11
Diuron	Karmex	1	2.7	0.10	0.11
Ethylmercury chloride	Ceresan Red	2	5.4	0.01	0.01
Hexachloro-benzene	HCB	2	5.4	0.04	0.04
Malathion		1	2.7	0.50	0.56
Maneb		1	2.7	0.25	0.28
Methylmercury dicyandiamide	Panogen	1	2.7	0.01	0.01
Parathion, ethyl		1	2.7	0.09	0.10
Phenylmercury acetate	PMA	2	5.4	0.02	0.02
Propham	IPC	1	2.7	0.50	0.56
PENNSYLVANIA, 34 SITES					
Alachlor	Lasso	3	8.8	0.75	0.84
Atrazine	AAtrex	9	26.5	1.60	1.79
Butylate	Sutan	1	2.9	1.60	1.79
Captafol	Difolatan	1	2.9	1.00	1.12
2,4-D		3	8.8	0.58	0.65
Disulfoton	Di-Syston	1	2.9	0.50	0.56
Linuron	Lorox	1	2.9	0.50	0.56
Phorate	Thimet	1	2.9	2.50	2.80
SOUTH CAROLINA, 16 SITES					
Benefin	Balan	1	6.25	0.60	0.67
Captan		1	6.25	0.01	0.01
Carbaryl	Sevin	1	6.25	1.00	1.12
DDT		2	12.50	0.50	0.56
Methyl trithion		1	6.25	0.25	0.28
Mirex		1	6.25	0.01	0.01
Nitralin	Planavin	1	6.25	0.35	0.39
Parathion, ethyl		1	6.25	2.40	2.69
Parathion, methyl		1	6.25	0.25	0.28
Sulfur		1	6.25	38.40	43.04
Toxaphene		2	12.50	1.00	1.12
Trifluralin	Treflan	3	18.75	0.58	0.65
Vernolate	Vernam	1	6.25	2.00	2.24
SOUTH DAKOTA, 106 SITES					
Alachlor	Lasso	4	3.8	1.06	1.19
Atrazine	AAtrex	5	4.7	0.90	1.01
Bux		1	0.9	1.00	1.12
Captan		20	18.9	0.01	0.01
Carbofuran	Furadan	2	1.9	0.25	0.28
Chloramben	Amiben	1	0.9	2.00	2.24
2,4-D		27	25.5	0.41	0.45
Dieldrin		2	1.9	0.01	0.01
Dimethoate	Cygon	4	3.8	0.21	0.23
Disulfoton	Di-Syston	2	1.9	0.31	0.35
Malathion		18	17.0	0.01	0.01
MCPA		1	0.9	0.50	0.56

(Continued next page)

TABLE 3 (cont'd.). *Compounds applied to cropland sites by state, 1972—National Soils Monitoring Program*

Compound	Trade Name if Noted	Sites Reporting Application		Average Total Application	
		No.	%	Lb/Acre	Kg/Ha
Methoxychlor		1	0.9	0.01	0.01
Methylmercury dicyandiamide	Panogen	2	1.9	0.01	0.01
Parathion, ethyl		1	0.9	0.25	0.28
Propachlor	Ramrod	5	4.7	1.69	1.89
Phorate	Thimet	1	0.9	0.70	0.78
TENNESSEE, 22 SITES					
Alachlor	Lasso	1	4.5	2.00	2.24
Atrazine	AAtrex	3	13.6	1.60	1.79
Dimethoate	Cygon	1	4.5	2.00	2.24
Diuron	Karmex	1	4.5	0.11	0.12
Disulfoton	Di-Syston	1	4.5	0.72	0.81
Ethylmercury chloride	Ceresan Red	1	4.5	0.01	0.01
Folex		1	4.5	1.50	1.68
Fluometuron	Cotoran	2	9.1	0.91	1.01
Linuron	Lorox	2	9.1	0.63	0.70
MSMA		1	4.5	2.00	2.24
Paraquat		1	4.5	0.50	0.56
PCNB	Terrachlor	1	4.5	0.01	0.01
Prometryn		1	4.5	0.24	0.27
Trifluralin	Treflan	4	18.2	1.04	1.16
VIRGINIA, WEST VIRGINIA,[1] 24 SITES					
Atrazine	AAtrex	1	4.2	1.60	1.79
Carbaryl	Sevin	2	8.3	3.17	3.55
Dalapon		1	4.2	13.60	15.24
Naptalam	Alanap	1	4.2	1.50	1.68
Paraquat		1	4.2	0.50	0.56
Phorate	Thimet	1	4.2	0.70	0.78
Simazine		1	4.2	1.60	1.79
WASHINGTON STATE, 45 SITES					
Aldrin		1	2.2	0.05	0.06
Benzene hexachloride	BHC	2	4.4	1.25	1.40
Bromacil	Hyvar	1	2.2	0.75	0.84
Captan		5	11.1	0.03	0.03
Cycloate	Ro-Neet	1	2.2	0.25	0.28
2,4-D		12	26.7	1.31	1.47
Dicamba	Banvel D	1	2.2	0.25	0.28
Dieldrin		1	2.2	0.04	0.04
Diuron	Karmex	1	2.2	0.50	0.56
EPTC	Eptam	1	2.2	0.25	0.28
Hexachloro-benzene	No-Bunt	9	20.0	0.05	0.05
Heptachlor		1	2.2	0.01	0.01
MCPA		2	4.4	1.25	1.40
Mercury		3	6.7	0.01	0.01
Oxythioquinox	Morestan	1	2.2	0.08	0.09
Phenylmercury acetate	PMA	2	4.4	0.03	0.03
Phorate	Thimet	1	2.2	0.03	0.03
Propham	IPC	1	2.2	3.00	3.36
Propargite	Omite	1	2.2	1.50	1.68
Terbacil	Sinbar	1	2.2	1.50	1.68
WISCONSIN, 66 SITES					
Alachlor	Lasso	5	7.6	0.95	1.06
Atrazine	AAtrex	16	24.2	1.33	1.49
Captafol	Difolatan	1	1.5	0.50	0.56
Carbaryl	Sevin	1	1.5	1.50	1.68
Carbofuran	Furadan	1	1.5	6.00	6.72
Chlordane		1	1.5	8.00	8.97
Cyanazine	Bladex	1	1.5	1.50	1.68
2,4-D		4	6.1	0.69	0.78
Diazinon		1	1.5	0.01	0.01
EPTC	Eptam	1	1.5	2.00	2.24
Fensulfothion	Dasanit	1	1.5	0.75	0.84
Heptachlor		1	1.5	2.00	2.24
Linuron	Lorox	1	1.5	1.25	1.40
MCPB		2	3.0	0.63	0.70
Phorate	Thimet	5	7.6	5.32	5.96
Thiram	Arasan	1	1.5	0.01	0.01

[1] Because some small eastern states had very few sites, those with similar geographic location and/or agricultural characteristics were combined to obtain more representative data. State groups used were: Mid-Atlantic: Delaware, Maryland, and New Jersey; New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont; and Virginia and West Virginia.

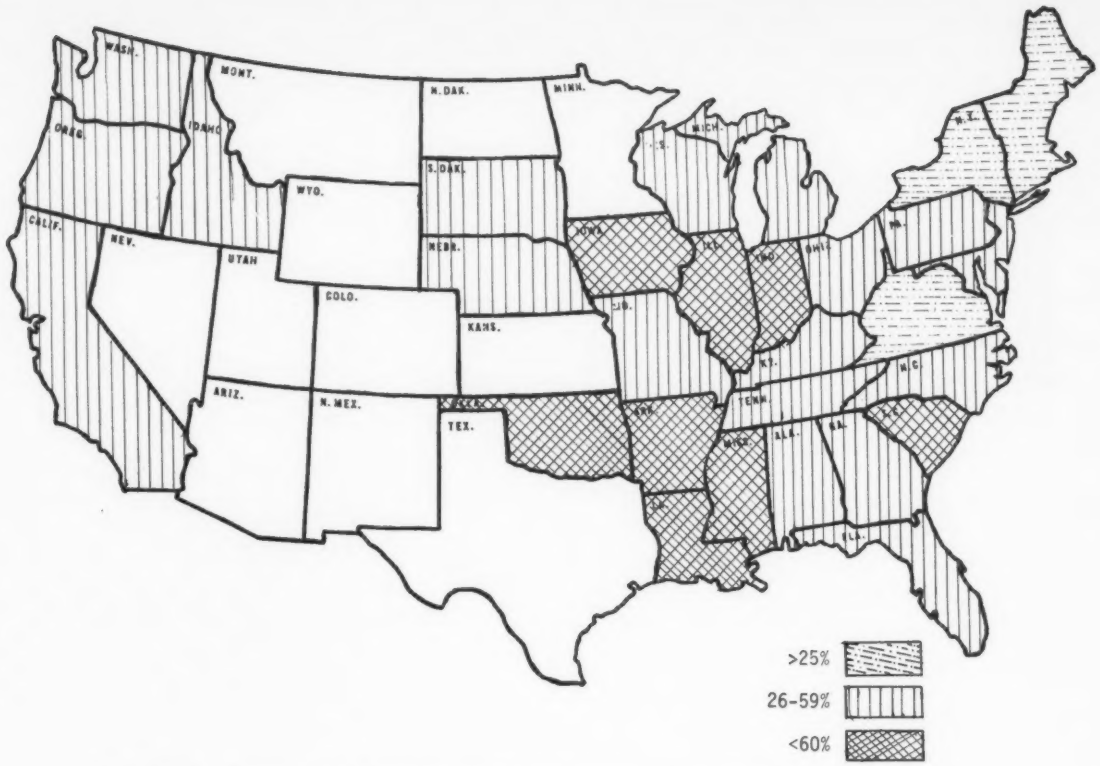

FIGURE 2. *Percent of sites reporting pesticide applications, 1972—National Soils Monitoring Program*

tion; and high, states where more than 60 percent of the sites reported pesticide application.

BY CROP

Table 4 lists crops grown on sample sites in 1972, and illustrates the diversity of crops grown in the United States. Application data for several major crops are presented in Table 5. Pesticide use varied widely among these crops. Thirty-nine different compounds were applied to field corn sites but only five compounds were applied to more than 10 percent of the sites. Cotton-growing sites also received applications of 39 compounds, but only 11 compounds were applied to more than 10 percent of the sites.

Table 6 shows pesticide applications on several crops by state. Differences in pesticide use among selected crops are apparent. For example, only 10.6 percent of the sites growing alfalfa and/or bur clover reported any pesticide applications, but 81.5 percent of the cotton sites did.

Acknowledgments

It is not possible to list all the persons who contributed to this study. However, the authors are especially grate-

TABLE 4. *List of crops grown on 1,402 sampling sites, 1972—National Soils Monitoring Program*

Crop	No. of Sites	Crop	No. of Sites
Field corn	364	Potatoes	3
Soybeans	266	Blueberries	2
Wheat	111	Apples	2
Mixed hay	105	Peaches	2
Alfalfa and/or bur clover	104	Turf	2
Pasture	66	Almonds	2
Cotton	54	Chick peas	2
Grass hay	42	Range	2
Oats	41	Sweet corn	2
Sorghum	24	Apricots	1
Barley	12	Plums	1
Oranges	9	*Lespedeza sericea*	1
Dry beans	9	Sweet clover	1
Silage (corn or sorghum)	8	Mint	1
Peas	7	Hops	1
Grapes	6	Sweet sorghum	1
Rye	6	Celery	1
Tobacco	5	Green peppers	1
Sugar beets	5	Lettuce	1
Rice	4	Pumpkins	1
Milo	4	Tomatoes	1
String beans	4	Millet	1
Pecans	3	Sunflowers	1
Flax	3	Other	9
Sugarcane	3	Fallow sites	129
Asparagus	3		

TABLE 5. *Compounds applied to cropland sites, by most common crop, 1972—National Soils Monitoring Program*

Compound	Sites Reporting Application		Average Total Application	
	No.	%	Lb/Acre	Kg/Ha
ALFALFA and BUR CLOVER, 104 SITES				
Carbaryl	3	2.9	2.33	2.61
Carbofuran	1	1.0	0.25	0.28
EPTC	1	1.0	2.00	2.24
IPC	1	1.0	3.00	3.36
Malathion	1	1.0	1.00	1.12
Methoxychlor	1	1.0	2.00	2.24
Parathion, ethyl	2	1.9	0.38	0.43
Picloram	1	1.0	0.75	0.84
Prolate	1	1.0	0.75	0.84
COTTON, 54 SITES				
Aldicarb	2	3.7	0.40	0.45
Azinphosmethyl	1	1.9	0.50	0.56
Captan	3	5.6	0.02	0.02
Carbaryl	1	1.9	1.00	1.12
Chloroneb	8	14.8	0.2	0.03
DDT	16	29.6	7.44	8.34
DEF	6	11.1	0.99	1.11
Dibromochloropropane	1	1.9	0.50	0.56
Dicrotophos	2	3.7	0.08	0.09
Dimethoate	1	1.9	2.00	2.24
Disulfoton	7	13.0	0.11	0.12
Diuron	9	16.7	0.80	0.90
DNBP	4	7.4	1.06	1.19
DSMA	8	14.8	2.51	2.81
EMTS	3	5.6	0.01	0.01
EPN	1	1.9	3.00	3.36
Ethylmercury chloride	1	1.9	0.01	0.01
Fenaminosulf	1	1.9	0.01	0.01
Fluometuron	22	40.7	0.98	1.09
Folex	5	9.3	1.10	1.23
Linuron	3	5.6	1.33	1.49
MCPB	2	3.7	0.50	0.56
Mercury	7	13.0	0.05	0.05
Methylmercury acetate	5	9.3	0.01	0.01
Monocrotophos	3	5.6	1.66	1.87
MSMA	20	37.0	2.38	2.67
Naled	1	1.9	1.00	1.12
Nitralin	2	3.7	0.88	0.98
Norea	2	3.7	1.10	1.23
Paraquat	1	1.9	0.02	0.02
Parathion, methyl	24	44.4	4.61	5.17
PCNB	1	1.9	0.01	0.01
Phorate	1	1.9	1.00	1.12
Prometryn	4	7.4	0.87	0.98
Propargite	1	1.9	1.68	1.88
Sodium chlorate	2	3.7	1.00	1.12
Thiram	1	1.9	0.01	0.01
Toxaphene	21	38.9	12.76	14.30
Trifluralin	3	55.6	0.91	1.02
FIELD CORN, 364 SITES				
Alachlor	36	9.9	1.19	1.33
Aldrin	31	8.5	1.67	1.88
Atrazine	188	51.8	1.56	1.74
Butylate	17	4.7	1.68	1.89
Bux	25	6.9	0.92	1.03
Captan	82	22.6	0.01	0.01
Carbaryl	1	0.3	1.33	1.49
Carbofuran	14	3.9	0.78	0.87
Chloramben	2	0.6	0.75	0.84
Chlordane	4	1.1	3.79	4.25
Cyanazine	1	0.3	2.80	3.14
2,4-D	73	20.1	0.62	0.69
Dalapon	1	0.3	13.60	15.24
Diazinon	5	1.4	1.10	1.13
Dicamba	10	2.8	0.38	0.43
Dicofol	1	0.3	1.00	1.12
Dieldrin	1	0.3	0.01	0.01
Disulfoton	1	0.3	0.50	0.56
Dyfonate	2	0.6	0.95	1.06
EPTC	2	0.6	5.21	5.84
Ethoprop	1	0.3	1.00	1.12
Fensulfothion	2	0.6	0.83	0.92
Heptachlor	4	1.1	1.58	1.77
Lindane	1	0.3	0.01	0.01
Linuron	3	0.8	0.95	1.06
Malathion	75	20.7	0.01	0.01
Methoxychlor	8	2.2	0.01	0.01
Methylmercury acetate	1	0.3	0.01	0.01
Mirex	2	0.6	0.01	0.01
Naptalam	1	0.3	0.83	0.93
Paraquat	1	0.3	0.50	0.56
Pentachlorophenol	1	0.3	0.05	0.06
Phorate	19	5.2	1.67	1.88
Propachlor	35	9.6	1.83	2.05
Simazine	2	0.5	2.80	3.14
TCBC	1	0.3	8.00	8.97
Thiram	4	1.1	0.01	0.01
Toxaphene	1	0.3	0.40	0.45
Trietazine	1	0.3	0.25	0.28
MIXED HAY, 105 SITES				
Carbofuran	1	1.0	1.00	1.12
Chlordane	1	1.0	0.75	0.84
2,4-D	2	1.9	0.42	0.47
EPTC	1	1.0	3.00	3.36
Malathion	1	1.0	0.50	0.56
Propham	1	1.0	0.50	0.56
SOYBEANS, 266 SITES				
Alachlor	44	16.5	1.54	1.72
Ancrack	4	1.5	1.08	1.20
Butyrac	1	0.4	0.40	0.45
Captan	5	1.9	0.01	0.01
Carbaryl	7	2.6	1.83	2.06
Chloramben	49	18.4	1.38	1.54
Chloropropham	1	0.4	0.59	0.66
Chloroxuron	1	0.4	2.00	2.24
2,4-D	4	1.5	0.96	1.07
2,4-DB	6	2.3	1.00	1.12
DDT	3	1.1	0.66	0.74
Dimethoate	1	0.4	0.66	0.74
Dinitrocresol	1	0.4	3.00	3.36
DNBP	9	3.4	1.54	1.73
Fluometuron	1	0.4	0.50	0.56
Linuron	32	12.0	1.11	1.24
Methyl trithion	1	0.4	0.25	0.28
Metribuzin	1	0.4	0.50	0.56
Mirex	1	0.4	0.01	0.01
MSMA	1	0.4	2.00	2.24
Naptalam	5	1.9	1.30	1.46
Nitralin	6	2.3	1.36	1.52
Paraquat	2	0.8	0.38	0.42
Parathion, methyl	6	2.3	0.71	0.79
Phorate	1	0.4	0.70	0.78
Propachlor	2	0.8	1.90	2.13
Simazine	1	0.4	3.00	3.36
Thiram	3	1.1	0.08	0.09
Toxaphene	5	1.9	1.00	1.12
Trifluralin	59	22.2	0.87	0.97
Vernolate	3	1.1	1.65	1.85
WHEAT, 111 SITES				
Aldrin	1	0.9	0.05	0.06
Benzene hexachloride	2	1.8	1.25	1.40
Bromacil	1	0.9	0.75	0.84
Captan	5	4.5	0.03	0.03
2,4-D	27	24.3	0.84	0.94
Dicamba	1	0.9	0.25	0.28
Diuron	1	0.9	0.50	0.56
EMTS	3	2.7	0.01	0.01
Ethylmercury chloride	4	3.6	0.01	0.01
Heptachlor	1	0.9	0.01	0.01
Hexachlorobenzene	10	9.0	0.05	0.06
Malathion	1	0.9	0.01	0.01
Mercury	2	1.8	0.01	0.01
Methylmercury dicyandiamide	1	0.9	0.01	0.01
Parathion, methyl	7	6.3	0.50	0.56
PCNB	6	5.4	0.02	0.03
Phenylmercury acetate	2	1.8	0.03	0.03
Thiram	2	1.8	0.01	0.01
Trifluralin	1	0.9	0.50	0.56

TABLE 6. *Pesticide applications on selected crops, by state, 1972—National Soils Monitoring Program*

State	ALFALFA/BUR CLOVER				COTTON			
	No. of Sites	Pesticides Applied	No Pesticides Applied	Pesticide Use Unknown	No. of Sites	Pesticides Applied	No Pesticides Applied	Pesticide Use Unknown
Alabama	0	—	—	—	3	3	—	—
Arkansas	0	—	—	—	13	12	1	—
California	8	2	4	2	4	2	1	1
Florida	0	—	—	—	0	—	—	—
Georgia	0	—	—	—	2	1	—	1
Idaho	5	1	4	—	0	—	—	—
Illinois	4	—	4	—	0	—	—	—
Indiana	4	—	4	—	0	—	—	—
Iowa	10	—	10	—	0	—	—	—
Kentucky	1	1	—	—	0	—	—	—
Louisiana	0	—	—	—	6	6	—	—
Michigan	5	—	5	—	0	—	—	—
Mid-Atlantic[1]	0	—	—	—	0	—	—	—
Mississippi	0	—	—	—	10	9	—	1
Missouri	2	—	2	—	6	6	—	—
Nebraska	10	—	9	1	0	—	—	—
New England[1]	0	—	—	—	0	—	—	—
New York	2	1	1	—	0	—	—	—
N. Carolina	0	—	—	—	0	—	—	—
Ohio	4	1	3	—	0	—	—	—
Oklahoma	3	2	1	—	7	2	5	—
Oregon	2	—	2	—	0	—	—	—
Pennsylvania	3	—	3	—	0	—	—	—
S. Carolina	0	—	—	—	0	—	—	—
S. Dakota	14	1	13	—	0	—	—	—
Tennessee	0	—	—	—	3	3	—	—
Virginia/W. Virginia[1]	0	—	—	—	0	—	—	—
Washington state	6	1	5	—	0	—	—	—
Wisconsin	21	1	20	—	0	—	—	—
Total	104	11	90	3	54	44	7	3
%	100.0	10.6	86.5	2.9	100.0	81.5	13.0	5.5
	FIELD CORN				SOYBEANS			
Alabama	7	1	6	—	2	2	—	—
Arkansas	0	—	—	—	25	16	9	—
California	2	1	—	1	0	—	—	—
Florida	1	1	—	—	1	—	1	—
Georgia	5	2	3	—	5	5	—	—
Idaho	1	1	—	—	0	—	—	—
Illinois	56	54	2	—	50	36	14	—
Indiana	27	25	2	—	24	19	5	—
Iowa	73	65	7	1	48	41	5	2
Kentucky	8	5	—	3	3	1	1	1
Louisiana	2	1	1	—	8	7	1	—
Michigan	22	18	4	—	4	4	—	—
Mid-Atlantic[1]	6	4	2	—	5	5	—	—
Mississippi	1	1	—	—	13	11	2	—
Missouri	16	14	2	—	23	18	4	1
Nebraska	31	26	5	—	3	2	1	—
New England[1]	0	—	—	—	0	—	—	—
New York	13	9	4	—	0	—	—	—
N. Carolina	8	4	4	—	9	4	5	—
Ohio	23	19	4	—	16	10	6	—
Oklahoma	0	—	—	—	0	—	—	—
Oregon	2	1	—	1	0	—	—	—
Pennsylvania	14	12	2	—	1	1	—	—
S. Carolina	1	1	—	—	10	7	3	—
S. Dakota	16	16	—	—	4	3	1	—
Tennessee	4	3	1	—	6	4	2	—
Virginia/W. Virginia[1]	1	1	—	—	5	2	2	1
Washington state	0	—	—	—	0	—	—	—
Wisconsin	24	17	5	2	1	1	—	—
Total	364	302	54	8	266	199	62	5
%	100.0	82.9	14.9	2.2	100.0	74.8	23.3	1.9
	WHEAT				MIXED HAY			
Alabama	0	—	—	—	1	—	1	—
Arkansas	0	—	—	—	1	—	1	—
California	2	—	1	1	1	1	—	—
Florida	0	—	—	—	0	—	—	—
Georgia	0	—	—	—	0	—	—	—
Idaho	4	4	—	—	3	—	3	—
Illinois	7	2	5	—	6	1	5	—
Indiana	9	—	9	—	0	—	—	—
Iowa	0	—	—	—	1	—	1	—
Kentucky	0	—	—	—	1	—	1	—

(Continued next page)

TABLE 6 (cont'd.). *Pesticide applications on selected crops, by state, 1972—National Soils Monitoring Program*

State	WHEAT				MIXED HAY			
	No. of Sites	Pesticides Applied	No Pesticides Applied	Pesticide Use Unknown	No. of Sites	Pesticides Applied	No Pesticides Applied	Pesticide Use Unknown
Louisiana	0	—	—	—	0	—	—	—
Michigan	0	—	—	—	8	—	8	—
Mid-Atlantic[1]	0	—	—	—	0	—	—	—
Mississippi	0	—	—	—	0	—	—	—
Missouri	5	—	5	—	11	—	11	—
Nebraska	14	—	12	2	0	—	—	—
New England[1]	0	—	—	—	2	—	2	—
New York	0	—	—	—	12	—	12	—
N. Carolina	0	—	—	—	0	—	—	—
Ohio	7	1	6	—	12	—	12	—
Oklahoma	25	16	9	—	0	—	—	—
Oregon	6	6	—	—	10	3	7	—
Pennsylvania	0	—	—	—	8	—	8	—
S. Carolina	0	—	—	—	1	—	1	—
S. Dakota	14	9	5	—	7	—	7	—
Tennessee	2	—	2	—	1	—	1	—
Virginia/W. Virginia[1]	0	—	—	—	8	—	8	—
Washington state	0	—	—	—	0	—	—	—
Wisconsin	16	15	1	—	12	—	12	—
Total	111	53	55	3	106	5	101	—
%	100.0	47.8	49.5	2.7	100.0	5.0	95.0	0

ful to the inspectors from the Plant Protection and Quarantine Programs, Animal and Plant Health Inspection Service, U.S. Department of Agriculture, for collecting the data.

LITERATURE CITED

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Pesticide Residue Levels in Soils and Crops from 37 States, 1972—National Soils Monitoring Program (IV)

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ABSTRACT

Residue data from the 1972 (FY–73) National Soils Monitoring Program are summarized. Composite samples of agricultural soil and mature crops were collected from 1,483 of the 1,533 selected 4-hectare sites in 37 states. Analyses were performed for organochlorine and organophosphorus compounds, trifluralin, and polychlorinated biphenyls (PCBs); analysis for atrazine was performed only when pesticide application data indicated current-year use. Organochlorine pesticides were detected in 45 percent of the soil samples. The most frequently detected compound was dieldrin, found in 27 percent of all soil samples. Other compounds detected, in order of frequency, included DDT, aldrin, chlordane, and heptachlor epoxide, found, respectively, in 21, 9, 8, and 7 percent of all soil samples. Crop samples were collected from 727 sites. All were analyzed for organochlorines; analyses were performed for organophosphates and atrazine only when pesticide application data indicated current-year use. For all crops, 40 percent of the samples contained detectable levels of organochlorines and 10 percent contained detectable levels of organophosphates. Atrazine was not detected.

Introduction

The National Pesticide Monitoring Program (NPMP) was initiated at the recommendation of the President's Science Advisory Committee in 1963 to "develop a continuing network to monitor residue levels in air, water, soil, man, wildlife and fish" (*8*). The primary objective of the NPMP is to determine levels and trends of pesticides and their degradation products in various components of the environment (*5*). The National Soils Monitoring Program (NSMP) was established in 1968 as an integral part of NPMP to monitor residues in agricultural soils and raw agricultural crops.

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The present report summarizes soil and crop pesticide concentration data collected from 1,483 sampling sites in 37 states during 1972 (FY–73). Data were not collected from all conterminous states because of budgetary limitations. The states omitted from the survey were generally large, western states either having little widespread agriculture or growing primarily wheat and other small grains, which require fewer pesticides than do other nongrain crops.

Sampling Procedures

A total of 1,533 sites in 37 states were scheduled for sampling during late summer and fall of 1972 (Fig. 1). Site selection criteria, statistical design, and sampling techniques involved in the present study have been described (*3*, *8*). At each 4-hectare (10-acre) site, a composite soil sample and a composite mature crop sample, if available, were collected according to established procedures (*6*). In addition, information on cropping practices and a history of pesticide applications for the current cropping season were obtained in a personal interview with the landowner or operator. These data have been summarized and published separately (*1*).

Analytical Procedures

ORGANOCHLORINES AND ORGANOPHOSPHATES

Sample Preparation, Soil—A 100-g subsample was taken from a thoroughly mixed field sample. The subsample was moistened with 25 ml distilled water and extracted with 200 ml 3:1 hexane:isopropanol solvent by shaking for 4 hours on a reciprocating shaker. The isopropanol was removed by three distilled water washes and the hexane extract was dried through anhydrous sodium sulfate. The sample extract was then stored at low temperature for subsequent gas-liquid chromatographic (GLC) analysis.

Crops—For samples containing less than 2 percent fat (e.g., alfalfa, bur clover, corn stalks, cotton stalks, green bolls, miscellaneous hay), a 100-g sample of the crop was dry blended for 3 minutes and then blended for 5

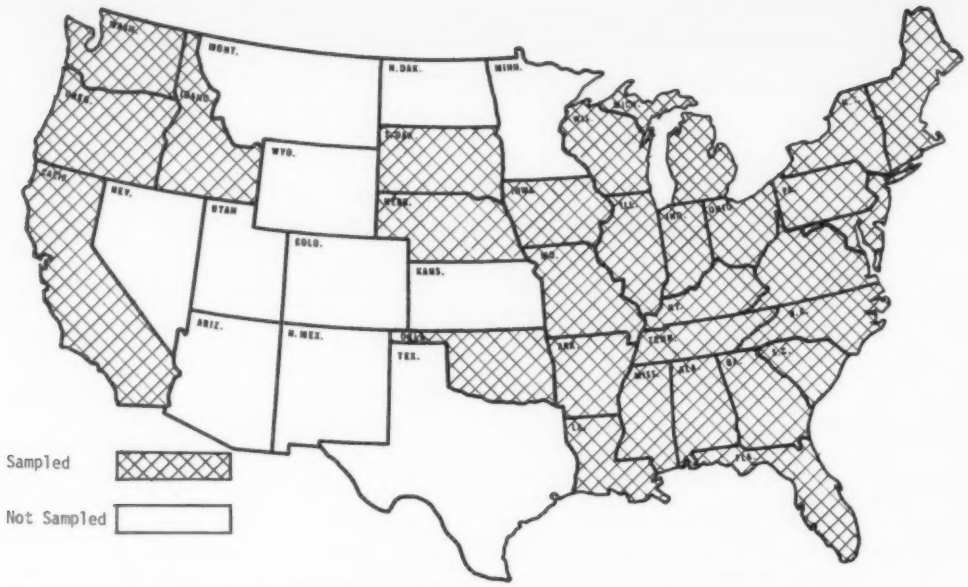

FIGURE 1. *States where agricultural soils and crops were sampled, 1972 (FY 1973) —National Soils Monitoring Program*

minutes in 800 ml acetonitrile. An aliquot of the sample extract, representing 10 g of the original sample, was decanted into a 500-ml Erlenmeyer flask. The extract was concentrated under a three-ball Snyder column to approximately 10 ml, 100 ml hexane was added, and the hexane–acetonitrile azeotrope was again concentrated to 10 ml. The process was carried out three times to remove essentially all acetonitrile. The hexane extract was dried through anhydrous sodium sulfate, the volume was adjusted to 50 ml, and the extract was stored at low temperature.

For crop samples containing more than 2 percent fat (e.g., corn kernels, cottonseed, soybeans), a 100-g sample was prewashed with 100 ml isopropanol and then with 100 ml hexane. Both prewashes were discarded. The sample was extracted as described in the preceding paragraph. A separate aliquot of the extract, not subjected to Florisil cleanup, was reserved for flame photometric analysis for organophosphates.

Florisil Cleanup—An extract equivalent to 5 g original crop sample was fractionated through a 15-g Florisil column into two fractions by use of 100 ml 10 percent methylene chloride in hexane and 100 ml methylene chloride for fractions 1 and 2, respectively.

Methylene chloride was removed by concentrating each extract to low volume under a three-ball Snyder column, adding 100 ml hexane, and concentrating again to low volume. After two additions of hexane, the methylene chloride was essentially removed. Each extract volume was adjusted to 2.5 ml for separate injection on the gas-liquid chromatograph.

GLC—Analyses were performed on gas chromatographs equipped with tritium foil electron-affinity detectors for organohalogens and thermionic or flame photometric detectors for organophosphates. A multiple-column system of polar and nonpolar columns was used to identify compounds. Instrument parameters and operating conditions follow:

Gas chromatographs:	Hewlett-Packard Model 402A Hewlett-Packard Model 402B Tracor Model MT-220	
Columns:	glass, 6 mm OD × 4 mm ID, 183 cm long, packed with one of the following: 5 percent OV-210 on 80–100-mesh Chromosorb W-HP; 3 percent DC-200 on 100–120-mesh Gas-Chrom Q; a mixture of 1.5 percent OV-17 and 1.95 percent QF-1 on 100–120-mesh Supelcoport	
Temperatures, °C:	thermionic detector housing	250
	detector (EC and FPD)	200
	injection port	250
	column OV-210	166
	column DC-200	170–175
	mixed column	185–190
Carrier gases:	5 percent methane–argon flowing at 80 ml/minute; prepurified nitrogen flowing at 80 ml/minute	

Sensitivity or minimum detection levels for organochlorines and trifluralin were 0.002–0.03 ppm except for combinations of polychlorinated biphenyls (PCBs), chlordane, toxaphene, and other chemicals which had minimum detectable levels of 0.05–0.1 ppm. Minimum detectable levels for organophosphates were approximately 0.01–0.03 ppm. Compounds detectable by this

methodology are listed in Table 1. When necessary, residues were confirmed on a Dohrmann microcoulometric detector or a Coulson electrolytic conductivity detector. Because trifluralin is detected by the organochlorine methodology, it appears with the organochlorine analyses in the tables.

TABLE 1. *Compounds detectable by chemical methodology of the present study*

ORGANOCHLORINES	
Alachlor	Endrin ketone
Aldrin	Heptachlor
Benzene hexachloride	Heptachlor epoxide
Chlordane	Hexachlorobenzene
ΣDDT	Isodrin
Dieldrin	Lindane (γ-BHC)
DCPA	Methoxychlor
Dicofol	Ovex
Endosulfan I	PCBs
Endosulfan II	PCNs
Endosulfan sulfate	Propachlor
Endrin	Toxaphene
ORGANOPHOSPHATES	
DEF	Parathion, ethyl
Diazinon	Parathion, methyl
Ethion	Ronnel
Malathion	Trithion
Phorate	
OTHER HALOGENATED HYDROCARBONS	
Trifluralin[1]	

[1] Although trifluralin is a dinitroaniline compound, it is detected by the organochlorine methodology and thus appears with organochlorines in Tables 2–7.

Recovery Studies—Pesticide recovery values from soil were 80–110 percent, but usually were close to 100 percent. Values from crops ranged from 70 to 100 percent, depending on the amount of pesticide present, the individual pesticide, and the type of crop involved. Residue concentrations detected in both soil and crop samples were corrected for recovery. Soil samples were also converted to a dry-weight basis.

ATRAZINE

To analyze soil samples for atrazine, a 50-g subsample was taken from a thoroughly mixed field sample. The subsample was placed in the Soxhlet thimble and moistened with 40 ml 1:1 distilled water:methanol. After addition of 250 ml nanograde methanol, the sample was extracted for 4 hours. The extract in the Soxhlet flask was evaporated to about 50 ml on a hot plate and by use of a three-ball Snyder column. The sample extract was then decanted into a 1-liter separatory funnel. The extract was partitioned three times with 150 ml Freon 113 each time. The Freon 113 fractions were combined and concentrated to incipient dryness on a rotary evaporator. The extract was dissolved in isooctane and adjusted to 5 ml for injection into a gas-liquid chromatograph.

GLC—A Coulson electrolytic conductivity cell detector in the nitrogen mode was used for detection and quantification of the atrazine. Positive samples were confirmed by alkali flame detection. Recovery rate was 90–110 percent; minimum detection level was 0.01 ppm.

Results and Discussion

Tables 2–5 show concentrations of pesticides in soil samples, and Tables 6–8 show concentrations of pesticides in mature agricultural crops. Soil concentration data are also summarized by all sites and by state or state groups. Most tables list the number of analyses, the number of times a compound was detected, percent occurrence of the compound, the arithmetic mean, the estimated geometric mean, and the minimum and maximum positive concentrations detected.

The estimated geometric mean is routinely presented in the tables as an alternative to the arithmetic mean as a measure of central tendency for the data evaluation. Pesticide residue data frequently contain a large number of zero values, resulting either from the absence of pesticides or their presence at levels below the analytical sensitivity. Such data are seldom distributed normally, as shown by tests for skewness and kurtosis, but often tend to approximate a log-normal distribution. After repeated tests for significant skewness and/or kurtosis, the log $(X + 0.01)$ transformation was used to determine the logarithmic means. The antilogs of these figures, minus 0.01, were taken to obtain the estimates of the geometric mean in the untransformed dimension. The estimated geometric mean was calculated only for those compounds with more than one positive detection.

COMPOUND CONCENTRATIONS IN CROPLAND SOIL

All Sites—Soil samples were received from 1,483 of the scheduled 1,533 sites in 37 states. Results of analyses for organochlorine and organophosphorus pesticides and atrazine are presented in Table 2. The most frequently detected chemical was dieldrin, found in 27 percent of all samples analyzed. Other compounds, in order of frequency, included ΣDDT, aldrin, chlordane, and heptachlor epoxide found, respectively, in 21, 9, 8, and 7 percent of all samples analyzed.

Table 3 lists the occurrence of pesticide residues in the agricultural soil samples collected during 1972. The frequency of detection varied widely among the states surveyed. The detection frequencies of atrazine appear to be much higher for individual states than in other analyses because atrazine analyses were performed only when site application records indicated its use during the current growing season.

Table 4 presents the percent incidence of residues of selected pesticides at specific levels. For most of the compounds listed, the highest percentage of positive

TABLE 2. *Compound concentrations in cropland soil for all sample sites in 37 states, 1972 (FY 1973) —National Soils Monitoring Program*

Compound	Positive Detections		Residues, ppm dry weight			
			Arithmetic Mean	Estimated Geometric Mean[1]	Extremes of Detected Values	
	No.	%			Min.	Max.
ORGANOCHLORINES (1,483 samples)						
Aldrin	129	8.7	0.03	0.002	0.01	13.28
Benzene hexachloride	1	0.1	<0.01	—	0.02	
Chlordane	117	7.9	0.05	0.003	0.01	7.89
DCPA	1	0.1	<0.01	—	0.18	
o,p'-DDE	10	0.7	<0.01	<0.001	0.01	0.09
p,p'-DDE	299	20.2	0.05	0.006	0.01	7.16
o,p'-DDT	161	10.9	0.03	0.003	0.01	5.62
p,p'-DDT	275	18.5	0.13	0.007	0.01	18.93
o,p'-TDE	1	0.1	<0.01	—	0.31	
p,p'-TDE	46	3.1	0.01	0.001	0.01	8.20
ΣDDT	314	21.2	0.22	0.010	0.01	29.45
Dicofol	7	0.5	<0.01	<0.001	0.06	2.15
Dieldrin	403	27.2	0.04	0.008	0.01	6.18
Endosulfan I	1	0.1	<0.01	—	0.08	
Endosulfan II	1	0.1	<0.01	—	0.25	
Endosulfan sulfate	1	0.1	<0.01	—	0.31	
Endrin	10	0.7	<0.01	<0.001	0.01	2.13
Endrin ketone	2	0.1	<0.01	<0.001	0.02	0.38
Heptachlor	57	3.9	<0.01	0.001	0.01	0.60
Heptachlor epoxide	97	6.6	<0.01	0.001	0.01	0.72
Hexachlorobenzene	11	0.7	<0.01	<0.001	0.01	0.44
PCB	2	0.1	<0.01	<0.001	0.80	1.49
PCNB	3	0.2	<0.01	<0.001	0.22	2.61
Propachlor	1	0.1	<0.01	—	0.10	
Ronnel	1	0.1	<0.01	—	0.19	
Toxaphene	76	5.1	0.24	0.003	0.22	46.58
Trifluralin[2]	81	5.5	0.01	0.001	0.01	1.86
ORGANOPHOSPHATES (1,246 samples)						
DEF	4	0.3	<0.01	<0.001	0.06	0.67
Diazinon	3	0.2	<0.01	<0.001	0.07	0.17
Malathion	2	0.2	<0.01	<0.001	0.08	0.13
Parathion, ethyl	7	0.6	<0.01	<0.001	0.02	0.19
Parathion, methyl	1	0.1	<0.01	—	0.01	
Phorate	13	1.0	<0.01	<0.001	0.01	0.04
TRIAZINE (151 samples)						
Atrazine	134	88.7	0.10	0.051	0.01	0.77

[1] Not calculated when fewer than two positive detections present.
[2] See footnote, Table 1.

TABLE 3. *Occurrence of pesticide residues in cropland soils from 37 states, 1972—National Soils Monitoring Program*

State	Organochlorines[1]			Organophosphates			Atrazine[2]		
	No. of Analyses	Positive Detections		No. of Analyses	Positive Detections		No. of Analyses	Positive Detections	
		No.	%		No.	%		No.	%
Alabama	22	18	82	22	1	5	—		
Arkansas	43	37	86	43	0	—	—		
California	64	45	70	53	4	8	—		
Florida	17	12	71	17	0	—	1	0	—
Georgia	29	22	76	28	4	14	—		
Idaho	29	15	52	25	0	—	—		
Illinois	139	100	72	87	2	2	18	17	94
Indiana	78	27	35	59	0	—	4	4	100
Iowa	150	101	67	113	1	1	34	34	100
Kentucky	28	10	36	15	0	—	3	2	67
Louisiana	27	21	78	26	3	11	—		
Michigan	53	9	17	44	0	—	14	14	100
Mid-Atlantic[3]	14	7	50	14	0	—	1	0	—
Mississippi	30	25	83	25	3	12	—		
Missouri	82	33	40	66	0	—	13	13	100
Nebraska	101	39	39	86	0	—	19	17	90
New England[3]	20	7	35	20	0	—	—		
New York	36	13	36	35	0	—	6	6	100
N. Carolina	31	19	61	28	3	11	—		
Ohio	67	20	30	53	0	—	8	7	88
Oklahoma	64	7	11	64	0	—	—		
Oregon	37	11	30	33	0	—	—		
Pennsylvania	37	11	30	37	0	—	7	5	71
S. Carolina	17	15	88	17	1	6	—		
S. Dakota	106	12	11	90	2	2	—		
Tennessee	25	15	60	21	0	—	2	2	100
Virginia/W. Virginia[3]	25	6	24	25	0	—	2	0	—
Washington state	45	9	20	43	0	—	—		
Wisconsin	67	8	12	57	0	—	16	15	94

[1] Although trifluralin is a dinitroaniline compound, it is detected by the organochlorine methodology and thus appears with organochlorines in Tables 2–7.
[2] Samples analyzed only when application records indicated atrazine use during the current growing season.
[3] Because some small eastern states had very few sites, those with similar geographic location and/or agricultural characteristics were combined to obtain more representative data. State groups used were Mid-Atlantic: Delaware, Maryland and New Jersey; New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont; and Virginia and West Virginia.

TABLE 4. *Percent incidence of selected pesticides in cropland soil from all sampling sites in 37 states, 1972 —National Soils Monitoring Program*

Concentration, ppm dry wt	ΣDDT	Aldrin	Dieldrin	Chlordane	Heptachlor	Heptachlor Epoxide	Toxaphene	Trifluralin
Not detected	78.8	91.3	72.8	92.1	96.2	93.5	94.9	94.5
0.01– 0.25	11.7	7.3	23.6	3.3	3.6	6.4	0.1	5.0
0.26– 1.00	5.3	1.0	3.2	3.2	0.2	0.1	1.1	0.4
1.01– 5.00	3.1	0.3	0.3	1.3	—	—	2.6	0.1
5.01–10.00	0.7	—	0.1	0.1	—	—	0.9	—
>10.00	0.4	0.1	—	—	—	—	0.4	—
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 5. *Compound concentrations in cropland soils, by state, 1972—National Soils Monitoring Program*

Compound	Positive Detections		Residues, ppm dry weight			
			Arithmetic Mean Concentration	Estimated Geometric Mean[1]	Extremes of Detected Values	
	No.	%			Min.	Max.
ALABAMA						
Organochlorines,[2] 22 samples						
Chlordane	1	4.6	0.01	—	0.16	
p,p'-DDE	14	63.6	0.08	0.028	0.01	0.58
o,p'-DDT	8	36.4	0.03	0.009	0.01	0.19
p,p'-DDT	15	68.2	0.16	0.042	0.01	1.24
ΣDDT	15	68.2	0.27	0.062	0.01	1.97
Dieldrin	2	9.1	<0.01	0.001	0.01	0.01
Endrin	1	4.6	<0.01	—	0.10	
Ronnel	1	4.6	<0.01	—	0.19	
Toxaphene	7	31.8	0.67	0.038	0.22	5.94
Trifluralin	4	18.2	0.02	0.006	0.07	0.17
Organophosphates, 22 samples						
Phorate	1	4.6	<0.01	—	0.04	
ARKANSAS						
Organochlorines,[2] 43 samples						
Chlordane	2	4.6	<0.01	0.001	0.03	0.08
o,p'-DDE	1	2.3	<0.01	—	0.03	
p,p'-DDE	25	58.1	0.16	0.036	0.01	1.87
o,p'-DDT	22	51.2	0.13	0.027	0.01	0.92
p,p'-DDT	27	62.8	0.54	0.083	0.01	4.49
p,p'-TDE	5	11.6	0.02	0.002	0.01	0.45
ΣDDT	27	62.8	0.85	0.114	0.03	7.35
Dieldrin	10	23.3	0.02	0.005	0.01	0.24
Endrin	2	4.6	0.01	0.001	0.02	0.24
Toxaphene	11	25.6	1.01	0.033	0.48	9.11
Trifluralin	17	39.5	0.04	0.015	0.01	0.31
Organophosphates, 43 samples: no residues detected						
CALIFORNIA						
Organochlorines,[2] 64 samples						
Chlordane	2	3.1	0.02	0.001	0.02	1.02
o,p'-DDE	3	4.7	<0.01	0.001	0.01	0.03
p,p'-DDE	44	68.7	0.16	0.042	0.01	2.72
o,p'-DDT	23	35.9	0.06	0.011	0.01	1.38
p,p'-DDT	32	50.0	0.26	0.033	0.02	5.62
p,p'-TDE	7	10.9	0.01	0.002	0.01	0.27
ΣDDT	45	70.3	0.49	0.074	0.01	9.72
Dicofol	4	6.3	0.05	0.003	0.38	2.15
Dieldrin	7	10.9	0.01	0.002	0.01	0.36
Hexachlorobenzene	1	1.6	0.01	—	0.44	
PCBs	1	1.6	0.02	—	1.49	
Toxaphene	9	14.1	0.25	0.010	0.46	6.45
Trifluralin	1	1.6	<0.01	—	0.05	
Organophosphates, 53 samples						
DEF	1	1.9	<0.01	—	0.10	
Malathion	1	1.9	<0.01	—	0.13	
Parathion, ethyl	4	7.6	0.01	0.002	0.02	0.19
FLORIDA						
Organochlorines, 17 samples						
Aldrin	1	5.9	0.01	—	0.16	
Chlordane	4	23.5	0.03	0.007	0.02	0.22
p,p'-DDE	10	58.8	0.08	0.017	0.01	0.66
o,p'-DDT	2	11.8	0.03	0.004	0.02	0.56
p,p'-DDT	10	58.8	0.21	0.022	0.01	2.16
p,p'-TDE	1	5.9	0.04	—	0.74	
ΣDDT	11	64.7	0.37	0.035	0.01	3.38
Dicofol	3	17.6	0.03	0.006	0.06	0.23
Dieldrin	3	17.6	0.08	0.009	0.15	1.09
Heptachlor epoxide	1	5.9	<0.01	—	0.01	
Toxaphene	3	17.6	0.83	0.019	2.04	9.00
Organophosphates, 17 samples: no residues detected						
Triazines, 1 sample: no residues detected						
GEORGIA						
Organochlorines,[2] 29 samples						
Benzene hexachloride	1	3.4	<0.01	—	0.02	
Chlordane	1	3.4	<0.01	—	0.01	
o,p'-DDE	1	3.4	<0.01	—	0.01	
p,p'-DDE	20	69.0	0.11	0.031	0.01	1.30

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TABLE 5 (Cont'd.). *Compound concentrations in cropland soils, by state, 1972—National Soils Monitoring Program*

Compound	Positive Detections		Residues, ppm dry weight			
			Arithmetic Mean Concentration	Estimated Geometric Mean[1]	Extremes of Detected Values	
	No.	%			Min.	Max.
o,p'-DDT	6	20.7	0.08	0.008	0.04	1.71
p,p'-DDT	20	69.0	0.33	0.043	0.01	6.11
p,p'-TDE	2	6.9	0.01	0.002	0.03	0.15
ΣDDT	22	75.9	0.52	0.072	0.01	9.12
Dieldrin	4	13.8	<0.01	0.001	0.01	0.02
Endrin	1	3.4	<0.01	—	0.01	
Toxaphene	8	27.6	2.22	0.036	0.65	46.58
Trifluralin	2	6.9	<0.01	0.001	0.01	0.09
Organophosphates, 28 samples						
Phorate	4	14.3	<0.01	0.002	0.02	0.04
IDAHO						
Organochlorines, 29 samples						
Chlordane	1	3.4	0.01	—	0.20	
p,p'-DDE	11	37.9	0.02	0.008	0.01	0.13
o,p'-DDT	4	13.8	0.01	0.003	0.02	0.29
p,p'-DDT	10	34.5	0.05	0.009	0.01	0.96
p,p'-TDE	2	6.9	<0.01	0.001	0.01	0.04
ΣDDT	12	41.4	0.09	0.015	0.01	1.38
Dieldrin	11	37.9	0.01	0.006	0.01	0.04
Heptachlor epoxide	1	3.4	<0.01	—	0.04	
Hexachlorobenzene	1	3.4	<0.01	—	0.01	
Organophosphates, 25 samples: no residues detected						
ILLINOIS						
Organochlorines,[2] 139 samples						
Aldrin	51	36.7	0.14	0.009	0.01	12.69
Chlordane	38	27.3	0.22	0.020	0.04	3.97
o,p'-DDE	1	0.7	<0.01	—	0.03	
p,p'-DDE	10	7.2	<0.01	0.001	0.02	0.06
p,p'-DDT	10	7.2	<0.01	0.001	0.03	0.11
ΣDDT	12	8.6	0.01	0.002	0.02	0.16
Dieldrin	93	66.9	0.16	0.051	0.01	6.18
Endrin ketone	1	0.7	<0.01	—	0.02	
Heptachlor	31	22.3	0.01	0.004	0.01	0.60
Heptachlor epoxide	37	26.6	0.02	0.007	0.01	0.26
Trifluralin	9	6.5	0.01	0.001	0.02	0.27
Organophosphates, 87 samples						
Diazinon	2	2.3	<0.01	<0.001	0.15	0.17
Phorate	1	1.2	<0.01	—	0.40	
Triazines, 18 samples						
Atrazine	17	94.4	0.11	0.074	0.01	0.33
INDIANA						
Organochlorines,[2] 78 samples						
Aldrin	13	16.7	0.02	0.004	0.01	0.40
Chlordane	5	6.4	0.08	0.003	0.26	3.95
p,p'-DDE	1	1.3	<0.01	—	0.05	
p,p'-TDE	2	2.6	<0.01	<0.001	0.01	0.06
ΣDDT	2	2.6	<0.01	<0.001	0.01	0.11
Dieldrin	22	28.2	0.05	0.010	0.01	1.11
Heptachlor	4	5.1	<0.01	0.001	0.03	0.21
Heptachlor epoxide	4	5.1	<0.01	0.001	0.04	0.12
Trifluralin	4	5.1	0.01	0.002	0.06	0.60
Organophosphates, 59 samples: no residues detected						
Triazines, 4 samples						
Atrazine	4	100.0	0.08	0.075	0.03	0.11
IOWA						
Organochlorines,[2] 150 samples						
Aldrin	28	18.7	0.04	0.004	0.01	2.07
Chlordane	29	19.3	0.10	0.009	0.02	3.44
p,p'-DDE	16	10.7	0.01	0.002	0.01	0.33
o,p'-DDT	6	4.0	<0.01	0.001	0.01	0.24
p,p'-DDT	14	9.3	0.02	0.003	0.01	0.93
p,p'-TDE	2	1.3	<0.01	<0.001	0.01	0.01
ΣDDT	17	11.3	0.03	0.003	0.02	1.50
Dieldrin	85	56.7	0.09	0.029	0.01	1.62
Heptachlor	13	8.7	0.01	0.001	0.01	0.44
Heptachlor epoxide	27	18.0	0.01	0.003	0.01	0.20
PCBs	1	0.7	0.01	—	0.80	
Propachlor	1	0.7	<0.01	—	0.10	
Trifluralin	22	14.7	0.01	0.004	0.01	0.18

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TABLE 5 (Cont'd.). *Compound concentrations in cropland soils, by state, 1972—National Soils Monitoring Program*

Compound	Positive Detections		Residues, ppm dry weight			
			Arithmetic Mean Concentration	Estimated Geometric Mean[1]	Extremes of Detected Values	
	No.	%			Min.	Max.
Organophosphates, 113 samples						
Diazinon	1	0.9	<0.01	—	0.07	
Triazines, 34 samples						
Atrazine	32	94.1	0.21	0.114	0.01	0.77
KENTUCKY						
Organochlorines, 28 samples						
Chlordane	2	7.1	0.01	0.002	0.14	0.18
p,p'-DDE	3	10.7	<0.01	0.001	0.01	0.03
p,p'-DDT	3	10.7	<0.01	0.002	0.02	0.05
p,p'-TDE	2	7.1	<0.01	0.001	0.01	0.01
Σ DDT	4	14.3	0.01	0.002	0.01	0.08
Dieldrin	7	25.0	0.01	0.004	0.01	0.12
Heptachlor epoxide	2	7.1	<0.01	0.001	0.01	0.02
Organophosphates, 15 samples: no residues detected						
Triazines, 3 samples						
Atrazine	2	66.7	0.01	0.010	0.01	0.03
LOUISIANA						
Organochlorines,[2] 27 samples						
Aldrin	2	7.4	<0.01	0.001	0.01	0.05
p,p'-DDE	14	51.9	0.43	0.046	0.01	6.21
o,p'-DDT	10	37.0	0.41	0.030	0.01	5.62
p,p'-DDT	14	51.9	1.26	0.072	0.01	15.86
Σ DDT	14	51.9	2.09	0.100	0.03	27.69
Dieldrin	11	40.7	0.03	0.012	0.01	0.27
Endrin	1	3.7	0.02	—	0.48	
Toxaphene	8	29.6	3.51	0.065	2.08	29.99
Trifluralin	2	7.4	0.01	0.002	0.11	0.12
Organophosphates, 26 samples						
DEF	1	3.9	<0.01	—	0.08	
Phorate	2	7.7	<0.01	0.001	0.04	0.04
MICHIGAN						
Organochlorines,[2] 53 samples						
Aldrin	2	3.8	0.25	0.002	0.04	13.28
Chlordane	1	1.9	0.02	—	1.24	
DCPA	1	1.9	<0.01	—	0.18	
p,p'-DDE	6	11.3	0.24	0.005	0.02	7.16
o,p'-DDT	4	7.6	0.13	0.004	0.09	3.36
p,p'-DDT	5	9.4	0.67	0.006	0.05	18.93
p,p'-TDE	1	1.9	<0.01	—	0.10	
Σ DDT	6	11.3	1.04	0.007	0.02	29.45
Dieldrin	4	7.6	0.06	0.003	0.09	2.26
Hexachlorobenzene	1	1.9	<0.01	—	0.07	
Trifluralin	1	1.9	0.01	—	0.31	
Organophosphates, 44 samples: no residues detected						
Triazines, 14 samples						
Atrazine	14	100.0	0.09	0.062	0.01	0.41
MID-ATLANTIC[3]						
Organochlorines, 14 samples						
Chlordane	2	14.3	0.07	0.007	0.16	0.83
o,p'-DDE	1	7.1	0.01	—	0.09	
p,p'-DDE	4	28.6	0.15	0.013	0.04	1.83
o,p'-DDT	3	21.4	0.02	0.006	0.04	0.23
p,p'-DDT	4	28.6	0.12	0.014	0.02	1.17
p,p'-TDE	1	7.1	<0.01	—	0.07	
Σ DDT	4	28.6	0.30	0.020	0.06	3.32
Dieldrin	4	28.6	0.03	0.008	0.04	0.26
Endrin	1	7.1	0.02	—	0.25	
Heptachlor	1	7.1	<0.01	—	0.01	
Heptachlor epoxide	1	7.1	<0.01	—	0.07	
Organophosphates, 14 samples: no residues detected						
Triazines, 1 sample: no residues detected						
MISSISSIPPI						
Organochlorines,[2] 30 samples						
p,p'-DDE	24	80.0	0.23	0.087	0.02	1.54
o,p'-DDT	18	60.0	0.27	0.057	0.01	1.79
p,p'-DDT	24	80.0	1.12	0.239	0.02	8.76
p,p'-TDE	3	10.0	0.04	0.003	0 01	1.25

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TABLE 5 (Cont'd.). *Compound concentrations in cropland soils, by state, 1972—National Soils Monitoring Program*

Compound	Positive Detections		Residues, ppm dry weight			
			Arithmetic Mean Concentration	Estimated Geometric Mean[1]	Extremes of Detected Values	
	No.	%			Min.	Max.
ΣDDT	24	80.0	1.66	0.337	0.05	12.33
Dieldrin	3	10.0	<0.01	0.001	0.01	0.05
Toxaphene	16	53.3	2.21	0.185	0.49	12.77
Trifluralin	1	3.3	<0.01	—	0.05	
Organophosphates, 25 samples						
DEF	2	8.0	0.03	0.003	0.06	0.67
Phorate	1	4.0	<0.01	—	0.03	
MISSOURI						
Organochlorines,[2] 82 samples						
Aldrin	14	17.1	0.05	0.006	0.01	1.55
Chlordane	3	3.7	0.01	0.001	0.26	0.62
p,p'-DDE	6	7.3	<0.01	0.001	0.01	0.10
o,p'-DDT	3	3.7	<0.01	0.001	0.01	0.12
p,p'-DDT	6	7.3	0.01	0.002	0.06	0.51
ΣDDT	6	7.3	0.02	0.002	0.08	0.73
Dieldrin	26	31.7	0.05	0.012	0.01	0.60
Heptachlor	2	2.4	<0.01	0.001	0.05	0.07
Heptachlor epoxide	3	3.7	<0.01	0.001	0.01	0.06
Toxaphene	2	2.4	0.04	0.001	1.01	1.99
Trifluralin	6	7.3	0.02	0.003	0.04	0.68
Organophosphates, 66 samples: no residues detected						
Triazines, 13 samples						
Atrazine	13	100.0	0.07	0.055	0.01	0.17
NEBRASKA						
Organochlorines,[2] 101 samples						
Aldrin	2	2.0	<0.01	<0.001	0.01	0.06
Chlordane	8	7.9	0.01	0.002	0.01	0.19
p,p'-DDE	7	6.9	<0.01	0.001	0.01	0.36
o,p'-DDT	1	1.0	<0.01	—	0.12	
p,p'-DDT	6	5.9	0.01	0.001	0.01	0.50
ΣDDT	7	6.9	0.01	0.002	0.02	0.98
Dieldrin	34	33.7	0.03	0.009	0.01	0.29
Endrin	1	1.0	<0.01	—	0.01	
Heptachlor epoxide	5	5.0	<0.01	0.001	0.01	0.07
Organophosphates, 86 samples: no residues detected						
Triazines, 19 samples						
Atrazine	17	89.5	0.06	0.035	0.01	0.31
NEW ENGLAND[3]						
Organochlorines, 20 samples						
Chlordane	2	10.0	0.03	0.004	0.30	0.31
p,p'-DDE	6	30.0	0.24	0.012	0.02	4.34
o,p'-DDT	3	15.0	0.01	0.004	0.02	0.18
p,p'-DDT	5	25.0	0.20	0.015	0.04	2.49
p,p'-TDE	3	15.0	0.44	0.009	0.09	8.20
ΣDDT	6	30.0	0.90	0.022	0.03	15.03
Dieldrin	2	10.0	0.24	0.006	0.19	4.64
Endosulfan I	1	5.0	<0.01	—	0.08	
Endosulfan II	1	5.0	0.01	—	0.25	
Endosulfan sulfate	1	5.0	0.02	—	0.31	
Heptachlor epoxide	2	10.0	<0.01	0.002	0.03	0.06
Organophosphates, 20 samples: no residues detected						
NEW YORK						
Organochlorines, 36 samples						
Chlordane	1	2.8	0.03	—	1.02	
o,p'-DDE	2	5.6	<0.01	0.001	0.03	0.04
p,p'-DDE	9	25.0	0.06	0.007	0.01	1.26
o,p'-DDT	7	19.4	0.02	0.005	0.02	0.44
p,p'-DDT	9	25.0	0.13	0.012	0.05	3.14
o,p'-TDE	1	2.8	0.01	—	0.31	
p,p'-TDE	2	5.6	0.02	0.002	0.18	0.52
ΣDDT	9	25.0	0.24	0.016	0.08	5.06
Dieldrin	6	16.7	0.01	0.004	0.01	0.21
Endrin	1	2.8	0.01	—	0.24	
Heptachlor	1	2.8	<0.01	—	0.01	
Organophosphates, 35 samples: no residues detected						
Triazines, 6 samples						
Atrazine	6	100.0	0.06	0.045	0.01	0.21

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TABLE 5 (Cont'd.). *Compound concentrations in cropland soils, by state, 1972—National Soils Monitoring Program*

Compound	Positive Detections		Residues, ppm dry weight			
			Arithmetic Mean Concentration	Estimated Geometric Mean[1]	Extremes of Detected Values	
	No.	%			Min.	Max.
NORTH CAROLINA						
Organochlorines,[2] 31 samples						
Aldrin	1	3.2	<0.01	—	0.10	
Chlordane	2	6.4	0.05	0.002	0.02	1.39
p,p'-DDE	17	54.8	0.18	0.027	0.02	3.92
o,p'-DDT	13	41.9	0.04	0.013	0.01	0.26
p,p'-DDT	17	54.8	0.18	0.044	0.02	1.58
p,p'-TDE	4	12.9	0.01	0.003	0.02	0.28
ΣDDT	17	54.8	0.41	0.065	0.06	5.76
Dieldrin	10	32.3	0.03	0.007	0.01	0.32
Endrin	1	3.2	0.07	—	2.13	
Endrin ketone	1	3.2	0.01	—	0.38	
Heptachlor	1	3.2	<0.01	—	0.01	
Heptachlor epoxide	1	3.2	<0.01	—	0.03	
PCNB	1	3.2	0.03	—	0.98	
Toxaphene	4	12.9	0.47	0.010	1.07	11.03
Trifluralin	3	9.7	0.06	0.003	0.02	1.86
Organophosphates, 28 samples						
Parathion, ethyl	1	3.6	<0.01	—	0.12	
Phorate	3	10.7	<0.01	0.001	0.01	0.06
Triazines, 2 samples: no residues detected						
OHIO						
Organochlorines, 67 samples						
Aldrin	12	17.9	0.03	0.005	0.01	0.61
Chlordane	2	3.0	0.09	0.002	0.87	4.99
p,p'-DDE	2	3.0	<0.01	<0.001	0.02	0.04
p,p'-TDE	2	3.0	<0.01	0.001	0.05	0.06
ΣDDT	2	3.0	<0.01	0.001	0.08	0.09
Dieldrin	18	26.9	0.02	0.007	0.01	0.27
Heptachlor	2	3.0	0.01	0.001	0.16	0.29
Heptachlor epoxide	1	1.5	<0.01	—	0.07	
Organophosphates, 53 samples: no residues detected						
Triazines, 8 samples						
Atrazine	7	87.5	0.07	0.050	0.02	0.19
OKLAHOMA						
Organochlorines,[2] 64 samples						
p,p'-DDE	4	6.3	0.01	0.001	0.01	0.41
o,p'-DDT	2	3.1	<0.01	0.001	0.03	0.18
p,p'-DDT	3	4.7	0.01	0.001	0.05	0.30
ΣDDT	4	6.3	0.02	0.002	0.01	0.89
Dieldrin	1	1.6	<0.01	—	0.04	
Hexachlorobenzene	2	3.1	<0.01	0.001	0.03	0.12
PCNB	1	1.6	0.04	—	2.61	
Trifluralin	1	1.6	<0.01	—	0.08	
Organophosphates, 64 samples: no residues detected						
OREGON						
Organochlorines, 37 samples						
Chlordane	2	5.4	<0.01	0.001	0.02	0.05
p,p'-DDE	8	21.6	0.03	0.005	0.01	0.65
o,p'-DDT	3	8.1	0.01	0.002	0.03	0.35
p,p'-DDT	5	13.5	0.04	0.005	0.03	1.05
p,p'-TDE	1	2.7	<0.01	—	0.03	
ΣDDT	8	21.6	0.08	0.007	0.01	2.08
Dieldrin	4	10.8	0.01	0.003	0.03	0.19
Heptachlor epoxide	2	5.4	<0.01	<0.001	0.01	0.01
Toxaphene	2	5.4	0.03	0.003	0.55	0.64
Organophosphates, 33 samples: no residues detected						
PENNSYLVANIA						
Organochlorines,[2] 37 samples						
Chlordane	2	5.4	0.01	0.002	0.21	0.26
p,p'-DDE	7	18.9	0.04	0.006	0.01	0.72
o,p'-DDT	3	8.1	0.01	0.002	0.02	0.16
p,p'-DDT	6	16.2	0.03	0.005	0.02	0.61
ΣDDT	7	18.9	0.07	0.007	0.01	1.49
Dieldrin	6	16.2	0.01	0.004	0.03	0.23
Heptachlor epoxide	2	5.4	<0.01	0.001	0.01	0.05
Trifluralin	1	2.7	<0.01	—	0.13	
Organophosphates, 37 samples: no residues detected						
Triazines, 7 samples						
Atrazine	5	71.4	0.03	0.022	0.01	0.10

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TABLE 5 (Cont'd.). *Compound concentrations in cropland soils, by state, 1972—National Soils Monitoring Program*

Compound	Positive Detections		Residues, ppm dry weight			
	No. of	%	Arithmetic Mean Concentration	Estimated Geometric Mean[1]	Extremes of Detected Values Min.	Max.
SOUTH CAROLINA						
Organochlorines,[2] 17 samples						
o,p'-DDE	1	5.9	<0.01	—	0.03	
p,p'-DDE	15	88.2	0.16	0.088	0.02	0.38
o,p'-DDT	12	70.6	0.08	0.032	0.01	0.39
p,p'-DDT	15	88.2	0.40	0.159	0.02	1.11
p,p'-TDE	4	23.5	0.01	0.004	0.01	0.14
ΣDDT	15	88.2	0.64	0.263	0.04	1.88
Dieldrin	2	11.8	<0.01	0.002	0.01	0.05
Toxaphene	6	35.3	1.17	0.062	0.82	6.16
Trifluralin	4	23.5	0.01	0.003	0.01	0.05
Organophosphates, 17 samples						
Phorate	1	5.9	<0.01	—	0.04	
SOUTH DAKOTA						
Organochlorines, 106 samples						
Aldrin	3	2.8	<0.01	<0.001	0.01	0.05
Chlordane	2	1.9	<0.01	0.001	0.15	0.31
p,p'-DDE	1	0.9	<0.01	—	0.13	
o,p'-DDT	1	0.9	<0.01	—	0.03	
p,p'-DDT	1	0.9	<0.01	—	0.33	
p,p'-TDE	1	0.9	<0.01	—	0.01	
ΣDDT	1	0.9	<0.01	—	0.50	
Dieldrin	11	10.4	0.01	0.002	0.01	0.21
Endrin	1	0.9	<0.01	—	0.04	
Heptachlor epoxide	2	1.9	<0.01	<0.001	0.01	0.03
Organophosphates, 90 samples						
Malathion	1	1.1	<0.01	—	0.08	
Parathion, ethyl	2	2.2	<0.01	0.001	0.06	0.10
Parathion, methyl	1	1.1	<0.01	—	0.01	
TENNESSEE						
Organochlorines,[2] 25 samples						
Chlordane	1	4.0	0.32	—	7.89	
p,p'-DDE	8	32.0	0.02	0.008	0.01	0.25
o,p'-DDT	3	12.0	0.01	0.003	0.06	0.20
p,p'-DDT	8	32.0	0.04	0.011	0.03	0.32
p,p'-TDE	1	4.0	0.01	—	0.17	
ΣDDT	9	36.0	0.08	0.017	0.02	0.51
Dieldrin	6	24.0	0.04	0.007	0.02	0.41
Heptachlor epoxide	1	4.0	0.03	—	0.72	
PCNB	1	4.0	0.01	—	0.22	
Toxaphene	1	4.0	0.13	—	3.37	
Trifluralin	2	8.0	<0.01	0.002	0.05	0.07
Organophosphates, 2 samples: no residues detected						
Triazines, 2 samples						
Atrazine	2	100.0	0.02	0.018	0.01	0.03
VIRGINIA/WEST VIRGINIA[3]						
Organochlorines, 25 samples						
Chlordane	1	4.0	0.03	—	0.70	
p,p'-DDE	3	12.0	0.01	0.002	0.01	0.09
o,p'-DDT	2	8.0	<0.01	0.001	0.01	0.02
p,p'-DDT	3	12.0	0.01	0.002	0.01	0.13
ΣDDT	4	16.0	0.02	0.003	0.01	0.23
Dieldrin	3	12.0	0.01	0.003	0.03	0.15
Heptachlor epoxide	2	8.0	0.01	0.001	0.01	0.12
Organophosphates, 25 samples: no residues detected						
Triazines, 3 samples: no residues detected						
WASHINGTON STATE						
Organochlorines,[2] 45 samples						
p,p'-DDE	2	4.4	<0.01	0.001	0.05	0.06
o,p'-DDT	1	2.2	<0.01	—	0.01	
p,p'-DDT	1	2.2	<0.01	—	0.04	
ΣDDT	2	4.4	<0.01	0.001	0.05	0.11
Dieldrin	2	4.4	<0.01	0.001	0.02	0.03
Hexachlorobenzene	6	13.3	<0.01	0.002	0.01	0.03
Trifluralin	1	2.2	<0.01	—	0.06	
Organophosphates, 43 samples: no residues detected						

(Continued next page)

TABLE 5 (Cont'd.). *Compound concentrations in cropland soils, by state, 1972—National Soils Monitoring Program*

Compound	Positive Detections		Residues, ppm dry weight			
			Arithmetic Mean Concentration	Estimated Geometric Mean[1]	Extremes of Deteced Values	
	No.	%			Min.	Max.
WISCONSIN						
Organochlorines, 67 samples						
Chlordane	3	4.5	0.04	0.002	0.69	1.19
p,p'-DDE	3	4.5	0.01	0.001	0.05	0.42
o,p'-DDT	1	1.5	<0.01	—	0.08	
p,p'-DDT	2	3.0	0.01	0.001	0.06	0.41
Σ DDT	3	4.5	0.02	0.001	0.05	0.91
Dieldrin	6	9.0	0.01	0.002	0.03	0.13
Heptachlor	2	3.0	<0.01	0.001	0.02	0.06
Heptachlor epoxide	3	4.5	<0.01	0.001	0.01	0.06
Organophosphates, 57 samples: no residues detected						
Triazines, 16 samples						
Atrazine	15	93.8	0.04	0.030	0.01	0.13

[1]Not calculated when fewer than two positive detections present.
[2]See footnote 1, Table 1.
[3]See footnote 3, Table 3.

TABLE 6. *Occurrence of pesticide concentrations in standing agricultural crops from 1,483 sampling sites, 1972 —National Soils Monitoring Program*

Crop Materials	Organochlorines			Organophosphates			Triazines		
	No. of Analyses	Positive Detections		No. of Analyses	Positive Detections		No. of Analyses	Positive Detections	
		No.	%		No.	%		No.	%
Alfalfa/bur clover	43	25	58	39	3	7	—		
Asparagus	1	1	100	1	0	—	—		
Beans, dry	3	1	33	3	0	—	—		
Clover (*Trifolium*)	8	5	63	8	0	—	—		
Corn, sweet (kernels)	2	0	—	2	0	—	—		
Corn, field (kernels)	288	31	11	167	0	—	12	0	—
Corn stalks	283	132	47	247	6	2	16	0	—
Cotton stalks	40	39	98	40	32	80	—		
Cotton	2	0	—	2	0	—	—		
Cotton seed	38	31	82	32	13	41	—		
Grass hay	21	14	67	21	6	29	—		
Lespedeza	1	1	100	1	1	100	—		
Mixed hay	47	31	66	43	3	7	—		
Oat hay	1	0	—	1	0	—	—		
Pasture forage	10	5	50	9	1	11	—		
Peanut vines	2	2	100	2	0	—	—		
Soybean hay	1	1	100	—			—		
Sugar beet tops	1	0	—	—			—		
Silage (corn or sorghum)	3	1	33	2	1	50	—		
Milo	3	1	33	2	0	—	—		
Peanuts	9	6	67	3	0	—	—		
Peas	1	0	—	1	0	—	—		
Pecans	1	0	—	1	0	—	—		
Rye	1	1	100	1	0	—	—		
Sorghum (grain)	14	5	36	11	2	18	—		
Sorghum (stalks)	18	8	44	15	3	20	—		
Soybeans	199	73	37	66	0	—	—		
Sugarcane	2	0	—	2	0	—	—		
Sweet sorghum	2	2	100	—			—		
Tobacco	2	2	100	2	1	50	—		

TABLE 7. *Occurrence of organochlorine concentrations in selected, mature crops, from 1,483 sites by state or state group, 1972—National Soils Monitoring Program*

State	Field Corn, Kernels			Soybeans			Mixed Hay		
	No. of Analyses	Positive Detections		No. of Analyses	Positive Detections		No. of Analyses	Positive Detections	
		No.	%		No.	%		No.	%
Alabama	7	0	—	4	4	100	1	0	—
Arkansas	—			19	10	53	—		
California	—			—			—		
Florida	—			1	0		—		
Georgia	4	0	—	5	2	40	—		
Idaho	—			—			—		
Illinois	41	1	2	28	16	57	1	1	100
Indiana	24	4	17	14	6	43	—		
Iowa	71	1	1	41	17	41	1	1	100
Kentucky	6	0	—	3	0	—	1	1	100
Louisiana	1	0	—	7	3	43	—		
Michigan	21	1	5	4	0	—	10	10	100
Mid-Atlantic[1]	3	1	33	3	0	—	—		
Mississippi	—			15	1	7	—		
Missouri	10	0	—	15	6	40	1	1	100
Nebraska	27	2	7	3	0	—	1	1	100
New England[1]	—			—			8	1	13
New York	11	8	73	—			1	1	100
N. Carolina	6	0	—	9	1	11	—		
Ohio	18	3	17	9	0	—	11	7	64
Oklahoma	1	0	—	—			1	1	100
Oregon	—			—			—		
Pennsylvania	10	9	90	1	1	100	1	1	100
S. Carolina	—			7	1	14	1	1	100
S. Dakota	11	0	—	—			4	2	50
Tennessee	2	0	—	4	3	75	1	1	100
Virginia/W. Virginia[1]	1	1	100	4	0	—	3	1	33
Washington state	—			—			—		
Wisconsin	13	0	—	1	0	—	—		

[1] See footnote 3; Table 3.

TABLE 8. *Compound concentrations in standing agricultural crops, 1972—National Soils Monitoring Program*

Compound	Positive Detections		Residues, ppm dry weight			
			Arithmetic Mean Concentration	Estimated Geometric Mean[1]	Extremes of Detected Values	
	No.	%			Min.	Max.
ALFALFA/BUR CLOVER						
Organochlorines, 43 samples						
Chlordane	7	16.3	0.02	0.005	0.04	0.24
p,p'-DDE	12	27.9	0.01	0.003	0.01	0.05
o,p'-DDT	12	27.9	0.01	0.004	0.01	0.09
p,p'-DDT	15	34.9	0.02	0.009	0.02	0.23
ΣDDT	15	34.9	0.04	0.012	0.03	0.28
Dieldrin	16	37.2	0.01	0.007	0.01	0.09
Heptachlor epoxide	1	2.3	<0.01	—	0.01	
Toxaphene	2	4.6	0.01	0.002	0.17	0.19
Organophosphates, 39 samples						
DEF	1	2.6	<0.01	—	0.02	
Diazinon	1	2.6	<0.01	—	0.01	
Malathion	3	7.7	0.01	0.002	0.03	0.26
ASPARAGUS						
Organochlorines, 1 sample						
p,p'-DDE	1	100.0	0.11	—	0.11	
o,p'-DDT	1	100.0	0.03	—	0.03	
p,p'-DDT	1	100.0	0.33	—	0.33	
ΣDDT	1	100.0	0.47	—	0.47	
Organophosphates, 1 sample: no residues detected						
BEANS, DRY (all varieties)						
Organochlorines, 3 samples						
Dicofol	1	33.3	0.05	—	0.15	
Organophosphates, 3 samples: no residues detected						
CLOVER (*Trifolium* sp.)						
Organochlorines, 8 samples						
Chlordane	2	25.0	0.02	0.008	0.07	0.10
p,p'-DDE	3	37.5	0.02	0.009	0.01	0.08
o,p'-DDT	4	50.0	0.03	0.014	0.01	0.07
p,p'-DDT	4	50.0	0.05	0.022	0.03	0.14
ΣDDT	4	50.0	0.10	0.031	0.04	0.29
Dieldrin	5	62.5	0.03	0.018	0.02	0.11
Organophosphates, 8 samples: no residues detected						
CORN, SWEET (kernels)						
Organochlorines, 2 samples: no residues detected						
Organophosphates, 2 samples: no residues detected						
CORN STALKS						
Organochlorines, 283 samples						
Alachlor	1	0.3	<0.01	—	0.09	
Chlordane	17	6.0	0.01	0.002	0.02	0.41
p,p'-DDE	28	9.9	<0.01	0.001	0.01	0.16
o,p'-DDT	37	13.1	<0.01	0.002	0.01	0.25
p,p'-DDT	62	21.9	0.02	0.004	0.01	2.33
p,p'-TDE	2	0.7	<0.01	<0.001	0.01	0.01
ΣDDT	62	21.9	0.03	0.005	0.01	2.74
Dieldrin	99	35.0	0.01	0.005	0.01	0.29
Endrin	3	1.1	<0.01	<0.001	0.01	0.04
Heptachlor	1	0.3	<0.01	—	0.01	
Heptachlor epoxide	14	5.0	<0.01	<0.001	0.01	0.06
Hexachlorobenzene	1	0.3	<0.01	—	0.02	
Toxaphene	9	3.2	0.04	0.002	0.19	4.14
Organophosphates, 247 samples						
Diazinon	2	0.8	<0.01	<0.001	0.04	0.10
Malathion	3	1.2	<0.01	<0.001	0.06	0.25
Phorate	4	1.6	<0.01	<0.001	0.01	0.02
Triazines, 16 samples: no residues detected						
FIELD CORN (kernels)						
Organochlorines, 288 samples						
Chlordane	2	0.7	<0.01	<0.001	0.01	0.15
o,p'-DDT	1	0.3	<0.01	—	0.03	
p,p'-DDT	2	0.7	<0.01	<0.001	0.03	0.07
ΣDDT	2	0.7	<0.01	<0.001	0.03	0.10
Dieldrin	8	2.8	<0.01	0.001	0.01	0.21

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TABLE 8 (Cont'd.). *Compound concentrations in standing agricultural crops, 1972—National Soils Monitoring Program*

Compound	Positive Detections		Residues, ppm dry weight			
	No.	%	Arithmetic Mean Concentration	Estimated Geometric Mean[1]	Extremes of Detected Values Min.	Max.
Endrin	2	0.7	<0.01	<0.001	0.01	0.02
Heptachlor	1	0.3	<0.01	—	0.02	
Heptachlor epoxide	23	8.0	<0.01	0.001	0.01	0.02
PCNB	1	0.3	<0.01	—	0.01	
Organophosphates, 167 samples: no residues detected						
Triazines, 12 samples: no residues detected						
COTTON STALKS						
Organochlorines,[2] 40 samples						
Chlordane	6	15.0	0.05	0.006	0.15	1.00
o,p'-DDE	1	2.5	<0.01	—	0.13	
p,p'-DDE	29	72.5	0.67	0.089	0.01	8.89
o,p'-DDT	28	70.0	0.79	0.116	0.01	13.40
p,p'-DDT	38	95.0	7.36	0.739	0.02	102.00
p,p'-TDE	12	30.0	0.04	0.010	0.01	0.41
ΣDDT	38	95.0	8.87	0.913	0.02	115.79
Dieldrin	14	35.0	0.02	0.008	0.01	0.19
Endosulfan sulfate	1	2.5	0.07	—	2.70	
Endrin	2	5.0	0.01	0.002	0.15	0.15
Heptachlor epoxide	3	7.5	<0.01	0.001	0.01	0.02
Toxaphene	28	70.0	25.44	1.078	0.66	462.30
Trifluralin	1	2.5	<0.01	—	0.02	
Organophosphates, 40 samples						
Carbophenothion	1	2.5	<0.01	—	0.08	
DEF	25	62.5	1.20	0.069	0.01	24.19
Diazinon	1	2.5	<0.01	—	0.02	
Malathion	4	10.0	0.03	0.003	0.01	0.94
Parathion, ethyl	5	12.5	0.01	0.003	0.01	0.12
Parathion, methyl	16	40.0	0.15	0.026	0.02	1.39
Phorate	1	2.5	<0.01	—	0.01	
COTTON SEED						
Organochlorines, 38 samples						
p,p'-DDE	16	42.1	0.01	0.008	0.01	0.12
o,p'-DDT	15	39.5	0.03	0.012	0.02	0.19
p,p'-DDT	31	81.6	0.22	0.082	0.01	1.40
p,p'-TDE	2	5.3	<0.01	0.001	0.04	0.14
ΣDDT	31	81.6	0.27	0.091	0.01	1.79
Dieldrin	2	5.3	<0.01	0.001	0.01	0.03
Toxaphene	20	52.6	0.49	0.082	0.20	3.71
Organophosphates, 32 samples						
DEF	13	40.6	0.09	0.016	0.02	0.71
Parathion, methyl	2	6.3	<0.01	0.001	0.04	0.05
COTTON						
Organochlorines, 2 samples: no residues detected						
Organophosphates, 2 samples: no residues detected						
SILAGE						
Organochlorines, 3 samples						
Chlordane	1	33.3	0.05	—	0.16	
p,p'-DDT	1	33.3	<0.01	—	0.01	
ΣDDT	1	33.3	<0.01	—	0.01	
Organophosphates, 2 samples						
Diazinon	1	50.0	0.05	—	0.11	
Malathion	1	50.0	1.32	—	2.64	
GRASS HAY						
Organochlorines, 21 samples						
Chlordane	2	9.5	0.01	0.003	0.09	0.09
o,p'-DDT	12	57.1	0.02	0.014	0.01	0.08
p,p'-DDT	13	61.9	0.07	0.033	0.01	0.23
p,p'-DDE	9	42.9	0.02	0.009	0.01	0.08
ΣDDT	13	61.9	0.11	0.044	0.01	0.30
Dieldrin	7	33.3	0.01	0.006	0.01	0.11
Toxaphene	6	28.6	0.15	0.020	0.30	1.19
Organophosphates, 21 samples						
DEF	1	4.8	0.01	—	0.12	
Diazinon	6	28.6	0.04	0.011	0.02	0.34
Malathion	5	23.8	0.03	0.007	0.02	0.22

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TABLE 8 (Cont'd.). *Compound concentrations in standing agricultural crops, 1972—National Soils Monitoring Program*

Compound	Positive Detections		Residues, ppm dry weight			
			Arithmetic Mean Concentration	Estimated Geometric Mean[1]	Extremes of Detected Values	
	No.	%			Min.	Max.
LESPEDEZA SERICEA						
Organochlorines, 1 sample						
p,p'-DDT	1	100.0	0.15	—	0.15	
ΣDDT	1	100.0	0.15	—	0.15	
Dieldrin	1	100.0	0.03	—	0.03	
Endrin	1	100.0	0.02	—	0.02	
Toxaphene	1	100.0	0.48	—	0.48	
Organophosphates, 1 sample						
DEF	1	100.0	0.15	—	0.15	
MILO						
Organochlorines, 3 samples						
p,p'-DDT	1	33.3	0.02	—	0.06	
p,p'-DDE	1	33.3	<0.01	—	0.01	
ΣDDT	1	33.3	0.02	—	0.07	
Toxaphene	1	33.3	0.04	—	0.13	
Organophosphates, 2 samples: no residues detected						
PASTURE FORAGE						
Organochlorines, 10 samples						
Chlordane	1	10.0	0.05	—	0.48	
o,p'-DDT	3	30.0	0.01	0.006	0.02	0.07
p,p'-DDT	4	40.0	0.08	0.021	0.08	0.40
p,p'-DDE	3	30.0	0.01	0.004	0.01	0.03
ΣDDT	4	40.0	0.10	0.026	0.17	0.40
Dieldrin	4	40.0	0.01	0.007	0.01	0.04
Toxaphene	2	20.0	0.15	0.014	0.59	0.86
Organophosphates, 9 samples						
Diazinon	1	11.1	<0.01	—	0.01	
MIXED HAY						
Organochlorines, 47 samples						
Chlordane	10	21.3	0.03	0.008	0.05	0.44
o,p'-DDE	1	2.1	<0.01	—	0.04	
p,p'-DDE	21	44.7	0.02	0.008	0.01	0.13
o,p'-DDT	23	48.9	0.02	0.009	0.01	0.12
p,p'-DDT	26	55.3	0.04	0.019	0.01	0.44
p,p'-TDE	1	2.1	<0.01	—	0.02	
ΣDDT	26	55.3	0.08	0.027	0.02	0.69
Dieldrin	22	46.8	0.02	0.012	0.01	0.11
Endrin	2	4.3	<0.01	<0.001	0.01	0.01
Heptachlor epoxide	1	2.1	<0.01	—	0.05	
Organophosphates, 43 samples						
Diazinon	2	4.6	<0.01	<0.001	0.01	0.02
Malathion	3	7.0	<0.01	0.001	0.02	0.09
Parathion, methyl	1	2.3	<0.01	—	0.01	
Phorate	1	2.3	<0.01	—	0.02	
PEANUTS						
Organochlorines, 9 samples						
p,p'-DDE	2	22.2	<0.01	0.003	0.02	0.02
ΣDDT	2	22.2	<0.01	0.003	0.02	0.02
Toxaphene	6	66.7	0.25	0.100	0.17	0.65
Organophosphates, 3 samples: no residues detected						
PEANUT VINES						
Organochlorines, 2 samples						
p,p'-DDT	1	50.0	0.42	—	0.85	
ΣDDT	1	50.0	0.42	—	0.85	
Dieldrin	2	100.0	0.21	0.102	0.02	0.41
Toxaphene	1	50.0	106.82	—	213.65	
Organophosphates, 2 samples: no residues detected						
PEAS (all varieties)						
Organochlorines, 1 sample: no residues detected						
Organophosphates, 1 sample: no residues detected						
PECANS						
Organochlorines, 1 sample: no residues detected						
Organophosphates, 1 sample: no residues detected						

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TABLE 8 (Cont'd.). *Compound concentrations in standing agricultural crops, 1972—National Soils Monitoring Program*

Compound	Positive Detections		Residues, ppm dry weight			
	No.	%	Arithmetic Mean Concentration	Estimated Geometric Mean[1]	Extremes of Detected Values Min.	Max.
RYE						
Organochlorines, 1 sample						
Chlordane	1	100.0	0.08	—	0.08	
Dieldrin	1	100.0	0.02	—	0.02	
Organophosphates, 1 sample: no residues detected						
SORGHUM (grain)						
Organochlorines, 14 samples						
o,p'-DDT	1	7.1	<0.01	—	0.02	
p,p'-DDT	5	35.7	0.01	0.006	0.01	0.07
p,p'-DDE	2	14.3	<0.01	0.001	0.01	0.02
ΣDDT	5	35.7	0.01	0.006	0.01	0.10
Dieldrin	2	14.3	<0.01	0.001	0.01	0.01
Organophosphates, 11 samples						
Malathion	2	18.2	0.03	0.006	0.04	0.29
Parathion, ethyl	1	9.1	<0.01	—	0.03	
Parathion, methyl	1	9.1	<0.01	—	0.01	
Phorate	1	9.1	<0.01	—	0.01	
SORGHUM STALKS						
Organochlorines, 18 samples						
Chlordane	1	5.6	0.01	—	0.15	
o,p'-DDT	5	27.8	0.01	0.004	0.01	0.03
p,p'-DDT	8	44.4	0.02	0.012	0.03	0.11
p,p'-DDE	6	33.3	0.01	0.004	0.01	0.04
p,p'-TDE	1	5.6	<0.01	—	0.07	
ΣDDT	8	44.4	0.04	0.017	0.04	0.20
Dieldrin	5	27.8	0.01	0.004	0.01	0.05
Toxaphene	1	5.6	0.01	—	0.25	
Organophosphates, 15 samples						
Malathion	3	20.0	0.02	0.006	0.06	0.13
Parathion, ethyl	1	6.7	<0.01	—	0.02	
SUGAR BEET TOPS						
Organochlorines, 1 sample: no residues detected						
SOYBEANS						
Organochlorines, 199 samples						
Chlordane	1	0.5	<0.01	—	0.07	
o,p'-DDT	1	0.5	<0.01	—	0.02	
p,p'-DDT	12	6.0	<0.01	0.001	0.01	0.07
p,p'-TDE	1	0.5	<0.01	—	0.18	
ΣDDT	13	6.5	<0.01	0.001	0.01	0.18
Dieldrin	47	23.6	<0.01	0.002	0.01	0.04
Endrin	16	8.0	<0.01	0.001	0.01	0.21
Heptachlor	1	0.5	<0.01	—	0.01	
Heptachlor epoxide	8	4.0	<0.01	<0.001	0.01	0.03
Toxaphene	12	6.0	0.01	0.002	0.14	0.38
Organophosphates, 66 samples: no residues detected						
SOYBEAN HAY						
Organochlorines, 1 sample						
o,p'-DDT	1	100.0	0.32	—	0.32	
p,p'-DDT	1	100.0	1.43	—	1.43	
p,p'-DDE	1	100.0	0.18	—	0.18	
ΣDDT	1	100.0	1.93	—	1.93	
Dieldrin	1	100.0	0.05	—	0.05	
Toxaphene	1	100.0	3.52	—	3.52	
SUGARCANE						
Organochlorines, 2 samples: no residues detected						
Organophosphates, 2 samples: no residues detected						
SWEET SORGHUM (grain)						
Organochlorines, 2 samples						
p,p'-DDT	1	50.0	0.07	—	0.14	
ΣDDT	1	50.0	0.07	—	0.14	
Dieldrin	1	50.0	<0.01	—	0.01	
Toxaphene	1	50.0	0.18	—	0.37	

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TABLE 8 (Cont'd.). *Compound concentrations in standing agricultural crops, 1972—National Soils Monitoring Program*

Compound	Positive Detections		Residues, ppm dry weight			
			Arithmetic Mean Concentration	Estimated Geometric Mean[1]	Extremes of Detected Values	
	No.	%			Min.	Max.
TOBACCO						
Organochlorines, 2 samples						
o,p'-DDT	1	50.0	0.03	—	0.07	
p,p'-DDT	2	100.0	0.48	0.385	0.19	0.77
p,p'-DDE	1	50.0	0.02	—	0.05	
ΣDDT	2	100.0	0.54	0.490	0.31	0.77
Dieldrin	2	100.0	0.04	0.043	0.03	0.06
Endrin	1	50.0	0.01	—	0.02	
Toxaphene	2	100.0	2.62	2.520	1.89	3.36
Organophosphates, 1 sample						
Diazinon	1	100.0	0.01	—	0.01	

[1] Not calculated when fewer than two positive detections present.
[2] Although trifluralin is a dinitroaniline compound, it is detected by the organochlorine methodology and thus appears with organochlorines in Tables 2–7.

detections was in the 0.01–0.25-ppm category, except for toxaphene, which was in the 1.01–5.00-ppm category.

By State—Pesticide concentrations in soils, by states or state groups, are presented in Table 5. Because some small eastern states had very few sites, those with similar geographic locations and/or agricultural characteristics were combined to obtain more representative data. State groups used were Mid-Atlantic: Delaware, Maryland, and New Jersey; New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont; and Virginia and West Virginia.

Comparisons of the percent occurrence of aldrin, dieldrin, heptachlor epoxide, ΣDDT, and chlordane are presented in Figures 2–6. The key for each figure is based on the arithmetic mean percent occurrence ($\bar{x}$) of the compound for all sites. The four classes are: greater than $2\bar{x}$, greater than $\bar{x}$ but less than $2\bar{x}$, greater than $\frac{1}{2}\bar{x}$ but less than $\bar{x}$, and less than $\frac{1}{2}\bar{x}$.

Illinois sites had the highest percent occurrence of aldrin, dieldrin, chlordane, and heptachlor epoxide (Figures 2–6). These compounds are soil insecticides, or their degradation products, used in corn production. The 1972 results generally correspond with results of the previous years for this Program (*2, 4, 7*). ΣDDT detections were concentrated in the southeastern states and California (Fig. 5). Oklahoma, Pennsylvania, South Dakota, and Wisconsin were generally below the all-sites average detection frequency for the compounds.

The detection of ronnel in soil from one site in Alabama (Table 5) was unusual. Ronnel is used to control flies, ticks, and gnats on domestic animals and in animal quarters. A thorough examination of the cropping and pesticide application record for that site revealed no pesticide applications during the growing season. However, the site was being used as a cattle pasture, and the chemical was probably transferred to the soil by treated cattle.

COMPOUND CONCENTRATIONS IN CROPS

Mature crop samples were collected from 737 sites, or 48 percent of the scheduled 1,533 sites. All crop samples were analyzed for organochlorines, including trifluralin. In addition, samples were analyzed for organophosphates and atrazine when pesticide application records indicated their use. Thus the organophosphate and atrazine concentration data samples are biased, and yield higher occurrence frequencies than might otherwise occur if all samples had been analyzed.

Table 6 lists the occurrence of pesticide residues in crop materials sampled. For all crops, 40 percent of the 1,045 samples analyzed contained detectable concentrations of organochlorines and 10 percent contained detectable amounts of organophosphates. Atrazine was not detected. In general, crops with known patterns of heavy pesticide application, or animal feed crops such as alfalfa, hay, field corn, or soybeans grown in rotation with these crops, had the highest detection frequencies.

Table 7 presents the occurrence of organochlorines in field corn kernels, soybeans, and mixed hay for each state or state group sampled. Residue detections varied most in field corn. Not enough samples were available to draw broad conclusions about mixed hay.

Table 8 presents the compound concentrations detected in each crop sampled. ΣDDT occurred most frequently in all crops except corn stalks, where dieldrin residues were predominant. The high frequency of occurrence of ΣDDT is probably the result of its prior, widespread use.

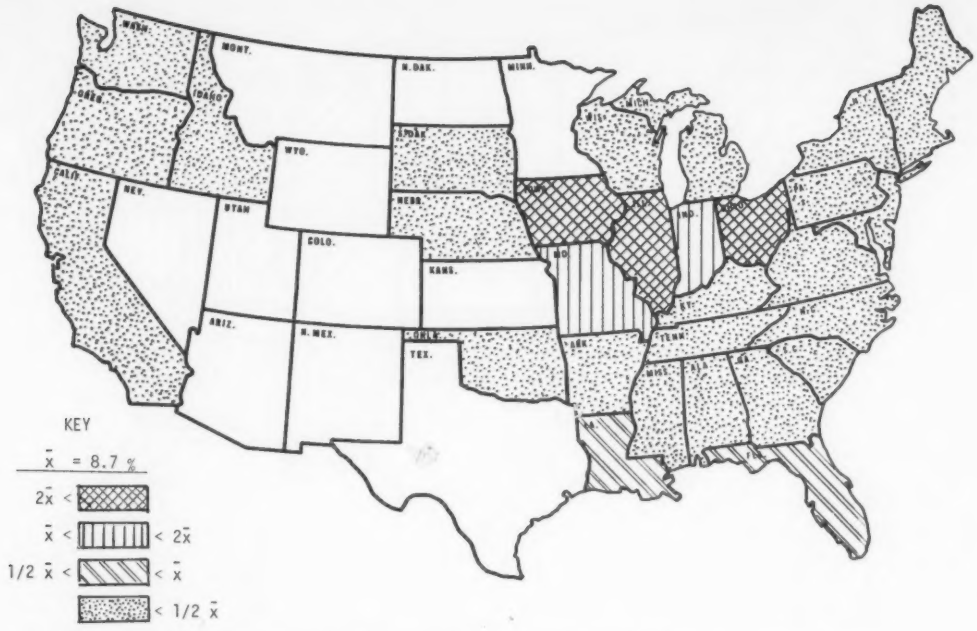

FIGURE 2. *Percent occurrence of aldrin residue detections in cropland soil of 37 states, by state, 1972 —National Soils Monitoring Program*

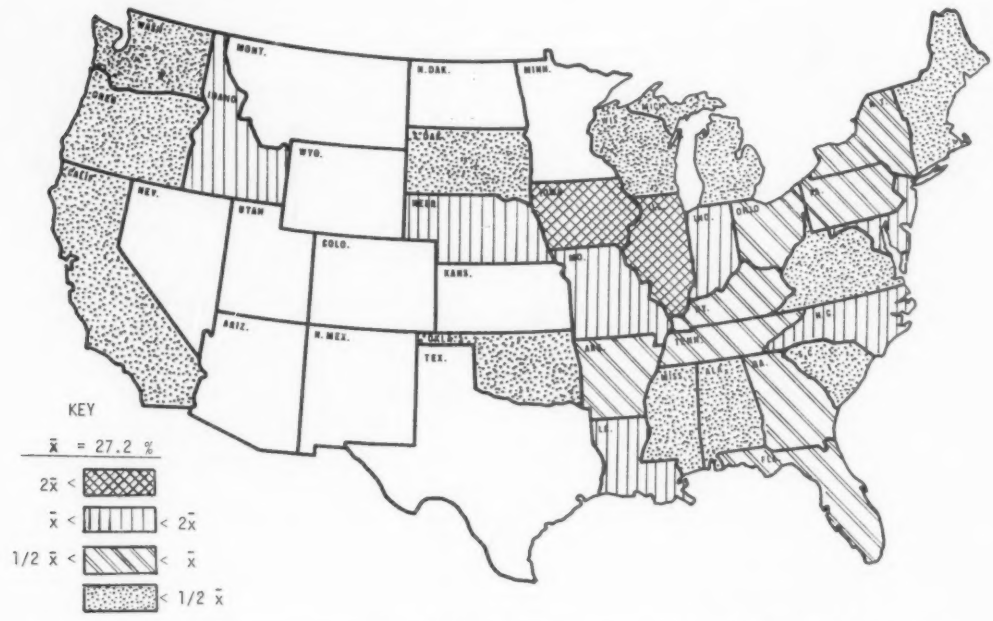

FIGURE 3. *Percent occurrence of dieldrin residue detections in cropland soil of 37 states, by state, 1972 —National Soils Monitoring Program*

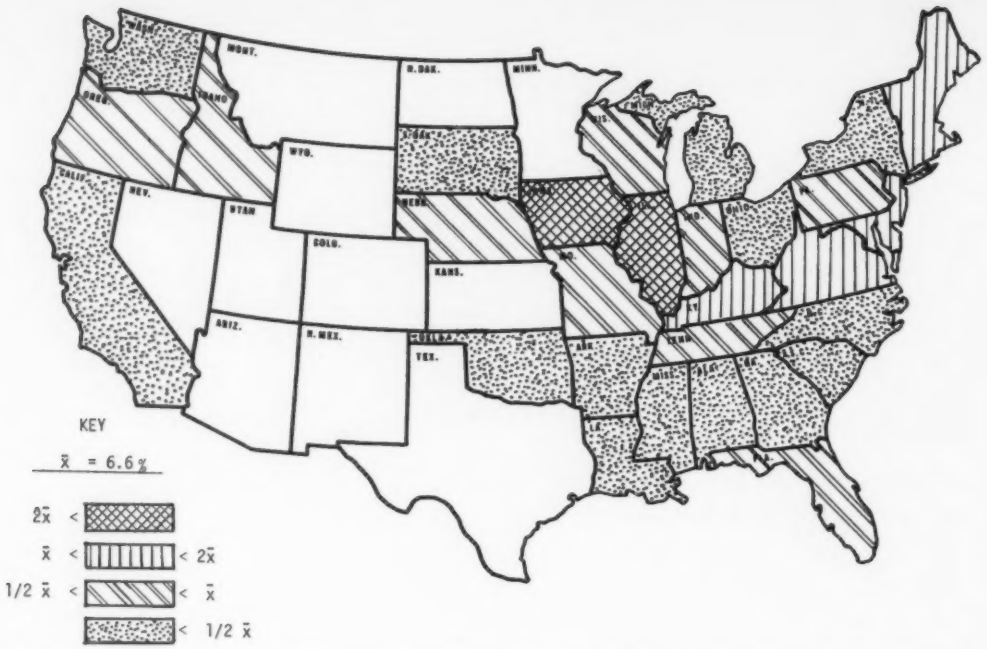

FIGURE 4. *Percent occurrence of heptachlor epoxide residue detections in cropland soil of 37 states, by state, 1972 —National Soils Monitoring Program*

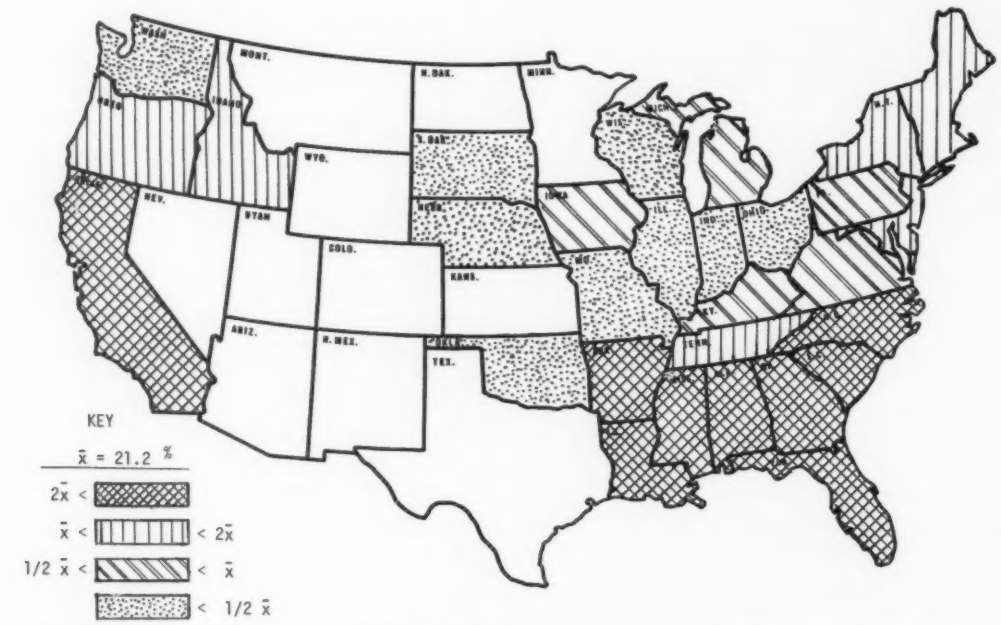

FIGURE 5. *Percent occurrence of ΣDDT residue detections in cropland soil of 37 states, by state, 1972 —National Soils Monitoring Program*

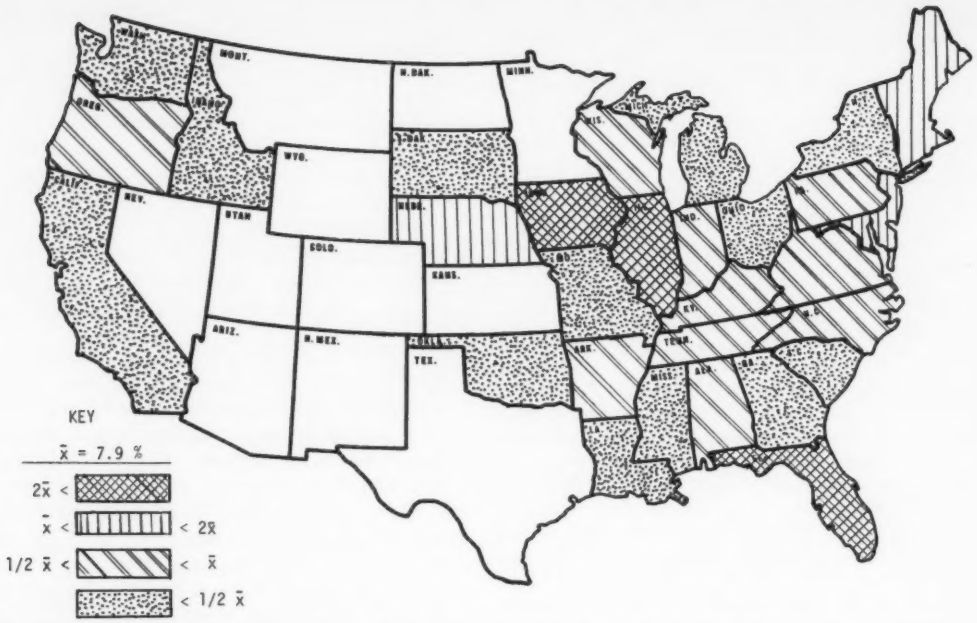

FIGURE 6. *Percent occurrence of chlordane residue detections in cropland soil of 37 states, by state, 1972 —National Soils Monitoring Program*

Acknowledgments

It is not possible to list by name all persons who contributed to this study. The authors are especially grateful to the staff of the Pesticides Monitoring Laboratory, Bay St. Louis, Mississippi, who received, processed, and analyzed samples for compound residues, and to the inspectors of the Animal and Plant Health Inspection Service, U.S. Department of Agriculture, who collected the samples.

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Organochlorine Pesticide Residues in Soils from Six U.S. Air Force Bases, 1975–76

Jerry T. Lang,[1] Leopoldo L. Rodriguez,[2] and James M. Livingston [2]

ABSTRACT

Soil samples collected during 1975 and 1976 from United States Air Force installations in California, Georgia, Ohio, Oklahoma, Texas, and Utah were analyzed for organochlorine pesticide residues. ΣDDT, chlordane, and dieldrin were the pesticides most commonly found. In 1975, ΣDDT residues were significantly higher in samples from residential areas than in samples from golf courses or areas free of pesticide application. Chlordane residues in 1975 were significantly higher in both residential and golf course areas than in areas where pesticides had not been used. No significant differences were found in 1976 in residue levels of any pesticide monitored among various land use areas.

Introduction

In 1975, the United States Air Force Occupational and Environmental Health Laboratory at Kelly Air Force Base, Texas, initiated a two-year pilot pesticides monitoring program to gather preliminary data on organochlorine residues in soils and sediments from Air Force bases and to determine the feasibility of developing a full-scale Air Force pesticides monitoring program. Only the baseline data on soil samples are discussed here. The feasibility study and the baseline data for sediment samples have been discussed elsewhere by Lang (*4*).

Sample Collection and Preparation

Six Air Force Logistics Command bases were sampled, including Hill AFB, Utah; Kelly AFB, Texas; McClellan AFB, California; Robins AFB, Georgia; Tinker AFB, Oklahoma; and Wright-Patterson AFB, Ohio. All bases represent urban environments with substantial industrialization and histories of considerable pesticide use.

Soil samples were collected from residential, open or nonuse, and golf course areas. Core samples from each use stratification were taken from the top 3 inches (7.6 cm) with a 3-inch (7.6-cm)-diameter bulb planter. Twenty core samples from each site were composited in a plastic bucket, thoroughly mixed by hand, and poured back and forth into a similar bucket. The composite sample was sieved through ¼-inch (6.4-mm) hardware cloth to remove large particles and debris. A subsample of the composite sample was placed in a clean hexane-rinsed 8-oz (240-ml) amber glass salve jar. Salve jars were capped with aluminum foil-lined lids and subsamples were kept frozen until being prepared for analysis. All sampling equipment was thoroughly rinsed with water after each stratum was sampled to avoid cross contamination.

At each residential sampling site, 10 individual core samples were taken from both sides of randomly selected streets. At those sites with sidewalks, all samples were taken within 1 ft (30.5 cm) of the sidewalk in the direction of the house. At sites without sidewalks, samples were taken approximately 4 ft (1.37 m) from the street. At each open sampling site, 10 core samples were collected at 45-ft (13.7-m) intervals along two parallel straight lines 45 ft (13.7 m) apart which originated at a randomly selected point. Golf course samples were collected from random starting points at 45-ft (13.7-m) intervals along both sides of the fairway at the edge of the rough.

Analytical Procedures

PREPARATION OF SAMPLES

Two grams of dry-sieved subsample (sieve size No. 14) were placed in a 15-ml test tube with a Teflon-lined screw cap, and 10 ml 3:1 hexane–isopropanol was added. Tubes were rotated for 4 hours, and the subsample was centrifuged. The solution was transferred to a 60-ml separatory funnel and washed three times with water to remove the alcohol. The solution was dried with anhydrous sodium sulfate, the solvent was reduced by evaporation, and the sample was cleaned by passage through a Florisil microcolumn. Subsample extracts were stored at low temperature for subsequent gas-chromatographic (GC) analysis.

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[2] U.S. Air Force Occupational and Environmental Health Laboratory, Brooks Air Force Base, TX 78235.

GAS CHROMATOGRAPHY

The analytical procedures were basically the same as those described by Wiersma et al. (*6*). Samples were analyzed for organochlorines and PCBs with a Tracor Model 222 gas chromatograph equipped with two Ni-63 electron-capture detectors (EC) and four glass columns. Two sets of polar and nonpolar columns were used to identify and confirm the organochlorine pesticides and PCBs. The gas chromatograph was equipped with a Model 8000 Varian Auto Sampler and interfaced with a Model 3354 Hewlett-Packard Data System. Instrument parameters and operating conditions follow:

Columns:	glass, 6 ft long, 6 mm OD × 4 mm ID, packed with (1) a mixture of 1.5 percent SP-2250 and 1.95 percent SP-2401 on 100–120-mesh Supelcon, AW, DMCS (2) a mixture of 4 percent SE-30 and 6 percent SP-2401 on 100–120-mesh Supelcon, AW, DMCS	
Temperatures, °C:	detector	300
	injection port	225
	column	200
Carrier gas:	5–10 percent methane–argon flowing at 60 ml/minute	

Compounds and their quantitative detectable levels are listed in Table 1. Minimum detectable levels of organochlorine pesticides were 0.01–2.00 mg/kg.

RECOVERY STUDIES

Recovery of the components listed in Table 1 ranged from 91 to 102 percent. Data presented in Tables 2 and 3 were not corrected for recovery.

Results and Discussion

Because a similar data pattern emerged on each base, data for a given year on the same pesticide on the same land use area were combined from all six bases (Table 2). ΣDDT residues were the most ubiquitous organochlorines on the six bases (Table 2). ΣDDT residues were also quantitatively higher overall than were residues of any other organochlorine except chlordane, which in 1975 had arithmetic mean levels consistently

TABLE 1. *Quantitative detection limits of organochlorines found in soils of six U.S. Air Force bases, 1975–76*

Compound	Residue, ppm
ΣDDT	0.05
Aldrin	0.01
Heptachlor	0.01
Lindane	0.01
Toxaphene	2.00
Chlordane	0.20
Dieldrin	0.02
Endrin	0.02
Heptachlor epoxide	0.01
Methoxychor	0.04
PCBs	0.40

TABLE 2. *Organochlorine residues in pooled soil samples from six U.S. Air Force installations, 1975–76*

	Residues, ppm dry wt															
	ΣDDT		Chlordane		Dieldrin		Heptachlor epoxide		Lindane		Heptachlor		Endrin		PCBs	
Statistic	75	76	75	76	75	76	75	76	75	76	75	76	75	76	75	76
Residential (20) (21)[1]																
Range	ND–3.83	ND–7.60	ND–52.11	ND–1.20	ND–0.04	ND–0.02	ND–0.03	ND–0.01	Tr	Tr	—	ND–0.16	ND–0.01	Tr	—	—
Average	0.86	0.63	5.43	0.16	0.01	<0.01	<0.01	<0.01	Tr	Tr	—	0.01	<0.01	Tr	—	—
% Pos. Sites	80.0	66.7	65.0	9.5	55.0	47.6	15.0	35.0	10.0	4.8	—	5.9	5.0	4.8	—	—
Nonuse (29) (29)[1]																
Range	ND–0.32	ND–13.93	ND–1.76	ND–3.44	ND–0.31	ND–0.10	ND–0.03	ND–0.06	—	Tr	—	—	—	ND–0.01	—	—
Average	0.06	0.94	0.09	0.18	0.01	0.01	<0.01	<0.01	—	Tr	—	—	—	<0.01	—	—
% Pos. Sites	48.0	44.8	24.0	14.0	17.4	24.0	17.0	14.3	—	3.5	—	—	—	7.0	—	—
Golf Course (17) (17)[1]																
Range	Tr–1.07	ND–0.69	ND–4.57	ND–3.05	ND–0.05	ND–0.03	ND–0.02	ND–0.01	—	Tr	—	—	—	—	ND–3.20	ND–4.33
Average	0.19	0.16	0.67	0.56	0.01	0.01	<0.01	<0.01	—	Tr	—	—	—	—	0.18	0.24
% Pos. Sites	70.6	58.8	58.8	35.3	23.5	23.5	11.8	17.7	—	5.9	—	—	—	5.9	5.9	5.9

NOTE: ND = nondetectable, Tr = trace.
[1]Number of samples collected from the indicated land use area in 1975 and 1976, respectively.

TABLE 3. *Geometric means and 95 percent confidence intervals for pooled ΣDDT, chlordane, and dieldrin residue data from use-stratified areas on six U.S. Air Force bases—1975–76*

Area	ΣDDT 95% CI Lower	ΣDDT Mean	ΣDDT 95% CI Upper	Chlordane 95% CI Lower	Chlordane Mean	Chlordane 95% CI Upper	Dieldrin 95% CI Lower	Dieldrin Mean	Dieldrin 95% CI Upper
1975 Residues, ppm									
Residential	0.0791	0.2276[a]	0.6549	0.0440	0.1875[a]	0.7153	0.0100	0.0246[a]	0.0606
Open	0.0124	0.0235[b]	0.0443	0.0091	0.0158[b]	0.0275	0.0089	0.0119[a]	0.0159
Golf course	0.0347	0.0599[b]	0.1033	0.0338	0.1049[a]	0.3253	0.0091	0.0122[a]	0.0163
1976 Residues, ppm									
Residential	0.0257	0.0782[a]	0.2382	0.0033	0.0150[a]	0.0694	0.0094	0.0117[a]	0.0145
Open	0.0134	0.0361[a]	0.0960	0.0100	0.0182[a]	0.0329	0.0099	0.0129[a]	0.0167
Golf course	0.0110	0.0437[a]	0.1729	0.0084	0.0320[a]	0.1218	0.0089	0.0110[a]	0.0136

NOTE: For a given year, means in a vertical column followed by the same letter are not significantly different at the 5 percent level.

higher than ΣDDT. The high arithmetic mean for chlordane residues in residential areas during 1975 was mainly attributable to the high levels found at Wright-Patterson AFB. This finding is notable in light of past problems with chlordane contamination in Capehart housing units on Wright-Patterson (*1, 2*). Except for chlordane levels found in residential soils in 1975, the arithmetic means shown in Table 2 closely approximate mean levels of the same pesticides in various nonmilitary urban areas of the United States (*3*).

Since residue data are not normally distributed, the arithmetic means in Table 2 are useful for comparison only in a relative sense. Therefore, the more statistically useful geometric means and associated 95 percent confidence limits based on data normalized with the ln $(X + 0.01)$ transformation discussed by Carey et al. (*3*) are given in Table 3 for the three most ubiquitous pesticides: ΣDDT, chlordane, and dieldrin.

To obtain an overall picture of the data, a three-factor analysis of variance was used to evaluate pesticide by land use by year interactions. The only significant interaction was for land use areas between the two years. Further examination showed that only the residential area means for 1975 and 1976 differed significantly ($P < 0.001$). There was no significant difference for the open area means ($P < 0.10$) and only an indication of a difference for the golf course means ($P < 0.10$).

One-way analyses of variance were used to evaluate data on a particular pesticide during a given year. Significant F values were found only for ΣDDT and chlordane in 1975. Bartlett's test (*5*) was used to check homogeneity of variances in the two cases. Variances were homogeneous for the ΣDDT data but not for the chlordane data. Therefore, standard t-tests were used to compare mean differences in ΣDDT data, and t'-tests (*5*) were used on the chlordane data.

In 1975, ΣDDT residues were significantly higher in residential areas than in open and golf course areas. Chlordane levels were significantly higher in both residential and golf course areas than in open areas. There was no significant difference in chlordane levels between residential and golf course areas.

Large differences between 1975 and 1976 ΣDDT and chlordane data (Table 3) are puzzling. From what is known generally of organochlorine degradation rates, microbial or other forms of degradation could not account for the decreases in ΣDDT and chlordane levels between 1975 and 1976. The most likely explanation for the rather drastic reduction in ΣDDT residues in residential areas and chlordane residues in residential and golf course areas between 1975 and 1976 is the irregular distribution of pesticide residues in the environment and the relatively small number of samples collected from each land use area.

Conclusions

Organochlorine residues on the six Air Force installations generally were the same generic type and quantity as those found in nonmilitary urban environments. ΣDDT residues were the most abundant followed by chlordane and dieldrin. Residential areas generally were contaminated more heavily with organochlorines than were open or nonuse and golf course areas. Large variations between 1975 and 1976 data on some pesticides indicate that, if the Air Force program is continued, more samples should be taken from each sampling site and increased emphasis should be placed on sampling protocol to ensure the gathering of comparative data.

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APPENDIX [1]

Chemical Names of Compounds Discussed in This Issue

ACEPHATE	*O,S*-Dimethyl acetylphosphoramidothioate
ALDRIN	Not less than 95% of 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-dimethanonaphthalene
CHLORDANE	1,2,3,4,5,6,7,8,8-Octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methanoindene. The technical product is a mixture of several compounds including heptachlor, chlordene, and two isomeric forms of chlordane.
DDE	Dichlorophenyl dichloro-ethylene (degradation product of DDT); *p,p'*-DDE: 1,1-Dichloro-2,2-bis(*p*-chlorophenyl) ethylene; *o,p'*-DDE: 1,1-Dichloro-2-(*o*-chlorophenyl)-2-(*p*-chlorophenyl) ethylene
DDT	Main component (*p,p'*-DDT): α-Bis(*p*-chlorophenyl) β,β,β,-trichloroethane. Other isomers are possible and some are present in the commercial product. *o,p'*-DDT: [1,1,1-Trichloro-2-(*o*-chlorophenyl)-2-(*p*-chlorophenyl) ethane]
DELNAV	2,3-*p*-Diozanedithiol *S,S*-bis (*O,O*-diethyl phosphorodithioate)
DIAZINON	*O,O*-Diethyl *O*-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate
DIELDRIN	Not less than 85% of 1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7:8,8a-octahydro-1,4-*endo-exo*-5,8-dimethanonaphthalene
DURSBAN	*O,O*-Diethyl *O*-(3,5,6-trichloro-2-pyridyl)
ENDRIN	Hexachloroepoxyoctahydro-*endo,endo*-dimethano-naphthalene
ETHION	*O,O,O',O'*-Tetraethyl *S,S'*-methylene bisphosphorodithioate
HCB	Hexachlorobenzene
HEPTACHLOR	1,4,5,6,7,8,8-Heptachloro-3a,4,7,7a-tetrahydro-4,7-*endo*-methanoindene
HEPTACHLOR EPOXIDE	1,4,5,6,7,8,8-Heptachloro-2,3-epoxy-3a,4,7,7a-tetrahydro-4,7-methanoindene
LINDANE	*Gamma* isomer of 1,2,3,4,5,6-hexachlorocyclohexane
MALATHION	*O,O*-Dimethyl dithiophosphate of diethyl mercaptosuccinate
METHAMIDOPHOS	*O,S*-Dimethyl phosphoramidothioate
MIREX	1,1a,2,2,3,3a,4,5,5,5a,5b,6-Dodecachlorooctahydro-1,3,4-metheno-1*H*-cyclobuta[cd]pentalene
NONACHLOR	1,2,3,4,5,6,7,8-Nonachlor-3a,4,7,7a-tetrahydro-4,7-methanoindan
OXYCHLORDANE	2,3,4,5,6,6a,7,7-Octachloro-1a,1b,5,5a,6,6a-hexahydro-2,5-methano-2*H*-indeno(1,2-β)oxirene
PCBs (Polychlorinated Biphenyls)	Mixtures of chlorinated biphenyl compounds having various percentages of chlorine
TDE	2,2-Bis(*p*-chlorophenyl)-1,1-dichloroethane (including isomers and dehydrochlorination products)
TOXAPHENE	Chlorinated camphene (67-69% chlorine). Product is a mixture of polychlor bicyclic terpenes with chlorinated camphenes predominating.
TRITHION	*S*-[[(*p*-Chlorophenyl)thio]methyl] *O,O*-diethyl phosphorodithioate

[1] Does not include compounds listed only in Carey and Gowen and in Carey et al.

ERRATA

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Page 99: Charles D. Kennedy and Roy L. Schutzmann, coauthors of the paper "Pesticide Residues in Estuarine Mollusks, 1977 versus 1972—National Pesticide Monitoring Program" are employed by the Ecological Monitoring Branch, Pesticides Monitoring Laboratory, U.S. Environmental Protection Agency, Bay St. Louis, MS 39520.

Pages 137–148: In the paper "Pesticide Application and Cropping Data from 37 States, 1971—National Soils Monitoring Programs," maps for Figures 1 and 2 were transposed.

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FEDERAL WORKING GROUP ON PEST MANAGEMENT
(RESPONSIBLE TO THE COUNCIL ON ENVIRONMENTAL QUALITY)

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